POWER PLANT ENGINEERING

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Power for a Federal Reserve Bank

NEW BANK BUILDING AT CLEVELAND, OHIO, REQUIRES UNFAILING RELIABILITY FROM ITS POWER EQUIPMENT

IN THE SAFEGUARDING of public wealth in a large bank, one of the most important things contributing towards a high factor of safety is a reliable and continuous supply of light and power. Darkness is the bank robber's best friend, and nothing so endangers the safety of the bank as an interruption of the lighting service. Such an interruption, whether it be due to an unforeseen failure of some part of the power equipment or whether it be brought about purposely by those who have designs against the bank, constitutes an emergency condition which the engineer must anticipate. He must select such equipment and so arrange it through interconnection that an interruption of service will be practically an impossibility.

These conditions have been met at this bank, first through the choice and arrangement of the power generating equipment and secondly, through an ingenious tie-in with the municipal power lines. Located on the main switchboard in the engine room is an automatic switch which throws the entire building demand for power and light upon the municipal power lines should there occur an interruption in the power supply from the three house generators. This emergency switch is manually operated when it is desired to cut the building back on the house power plant. As a further provision of safety this switch is interlocked so that the two line switches must be pulled before the neutral can be opened and conversely, the neutral must be in before the line switches can be cut in. The advantages of this arrangement are at once apparent when the extreme precautionary measures required for bank safety are given consideration.

FIG. 1. ARCHITECTURALLY, CLEVELAND'S FEDERAL RESERVE BANK BUILDING IS A CREDIT TO THE CITY

It is anticipated that normally all power and light will be furnished by the building power plant and for this purpose three engine generator units have been installed. The engines are 20 in. by 32-in. Nordberg-Todd uniflows and are equipped with auxiliary exhaust valves, the adjustment of which will allow regulation of the compression pressures. Steam pressure at the throttle will be 180 lb. gage with a superheat of 100 deg. F. Under ordinary conditions, the back pressure will be 2 lb. gage, at which pressure the exhaust steam will be used for heating the building during the winter months.

Each engine is direct connected to a 300-kw., 230-v. Crocker-Wheeler direct current generator, the normal operating speed of which is 150 r.p.m. Each main unit is equipped with a complete Phoenix-Richardson system of lubricators, filters and storage tanks. As is to be expected, head room is at a premium in this basement engine room, therefore to facilitate handling the heavy parts of the generating units, trolley beams have been permanently built into the ceiling over each engine. These beams run the full length of each engine and terminate at the head ends at a trolley beam which runs at right angles to the engine cylinder center lines. This arrangement will allow of heavy engine parts

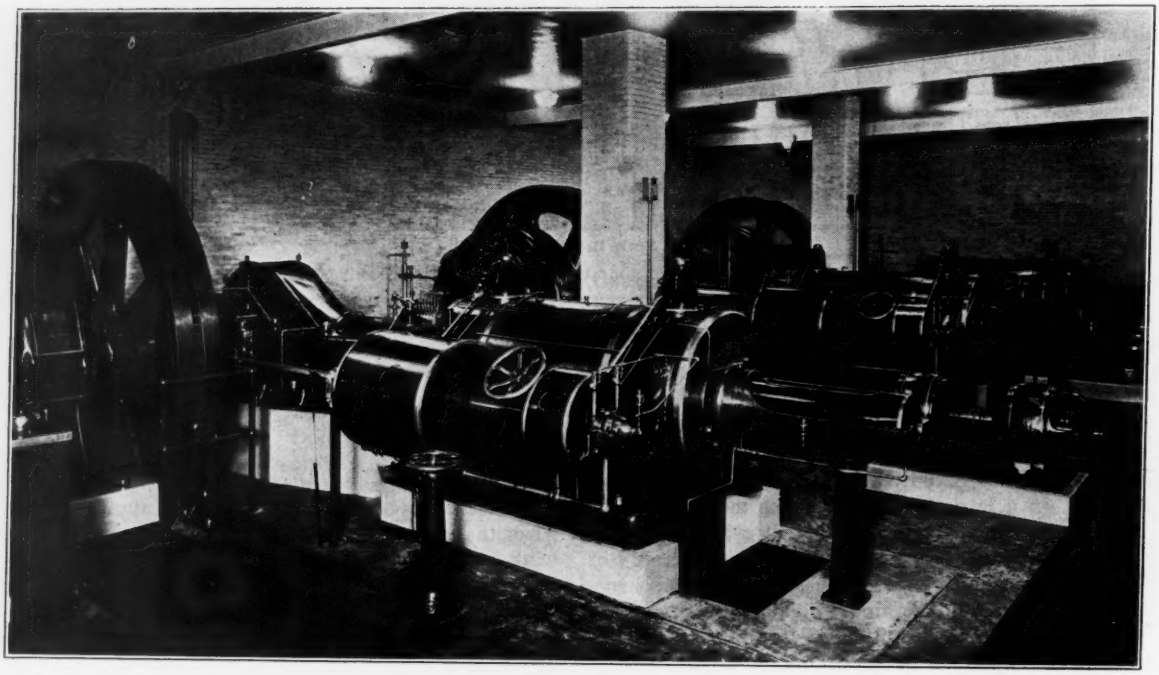


FIG. 2. THREE UNIFLOW ENGINES DEVELOP THE POWER REQUIRED TO SERVE THE ENTIRE BUILDING

being swung free of the aisles for complete removal of the part from the engine room or to clear the aisles between engines during extensive repairs.

Engine Safety Fully Provided for

Safety advantages to be derived from automatic engine stops have been provided by the installation of a 7-in. Strong, Carlisle and Hammond Co.'s stop valve on each engine lead. These stop valves are located just below the engine room floor and near the engine cylinder. Engine over speed will trip these stop valves and cut off all steam from the engines or for emergency or test purposes the stop valves may be manually tripped from the engine room operating floor.

High pressure steam is brought into the engine room basement by an 8-in. steam loop which is arranged so that expansion is cared for by means of long radius bends. Three engine leads are made up of long radius bends and are taken off the main steam loop so that practically no expansion strains will come on the engine cylinder. A steam separator is located on each engine lead and sectionalizing valves have been placed so that any one or more of the main units may be completely isolated. The exhaust or low pressure steam piping is also run under the engine room floor which results in an arrangement whereby the engine room proper is entirely free of steam piping.

Alarms Are Operated at Low Voltage

Attention has been given to safety features such as hand rails at the engine flywheels, and guards over the tail rods and mechanisms of the lay shafts. Mounted on the engine room floor are two motor generator booster sets which are rated at 100 amp., 125 v. and 1500 r.p.m.

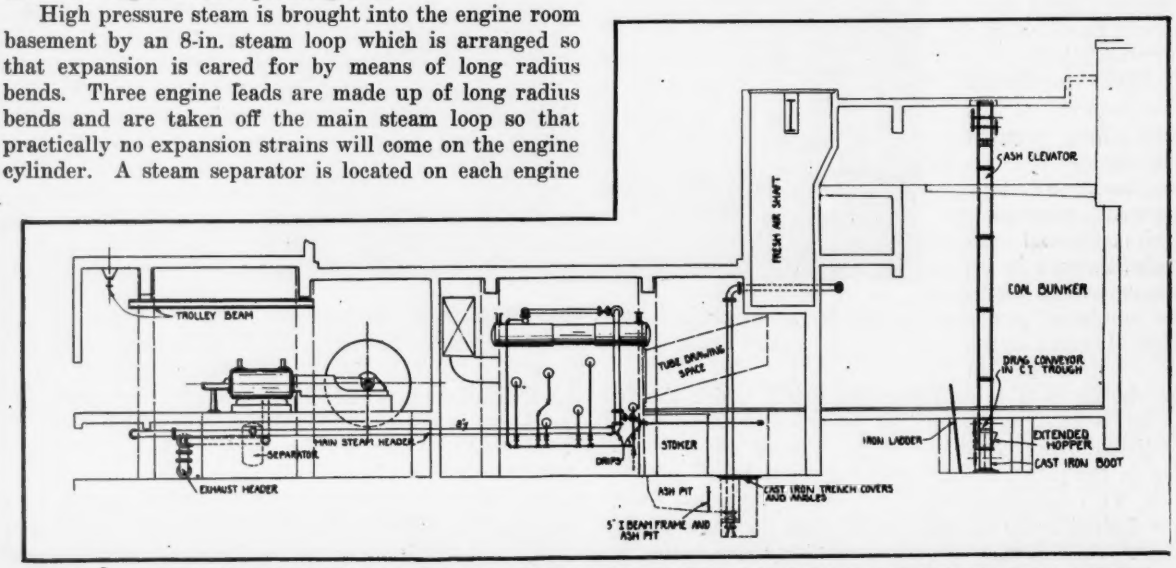


FIG. 3. SECTIONAL ELEVATION IN WHICH IS SHOWN THE RELATIVE LOCATION OF THE ENGINE ROOM, BOILERS AND COAL STORAGE

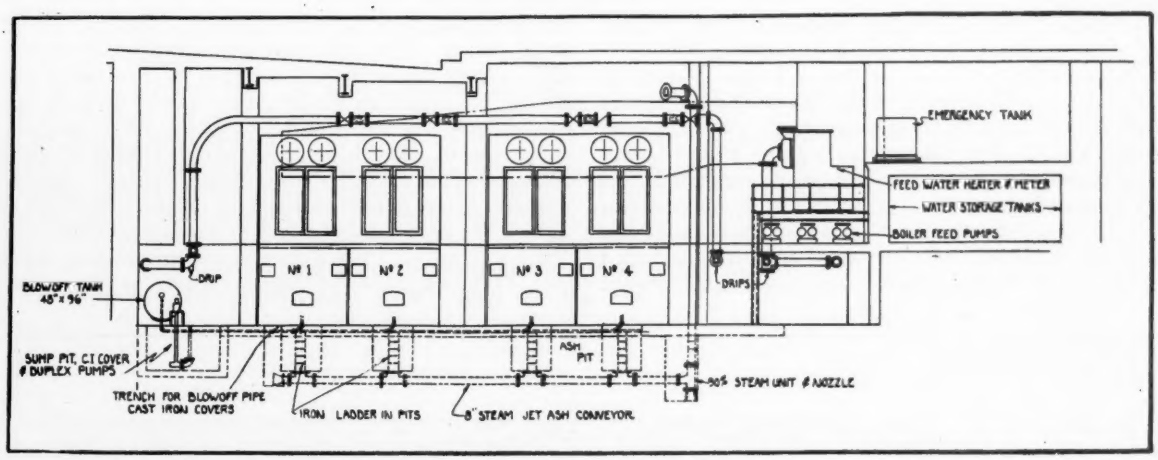


FIG. 4. ELEVATION SHOWING THE BOILER FRONTS, STEAM JET ASH DISPOSAL PIPE AND THE LOCATION OF THE FEED WATER PUMPS

Two Crocker-Wheeler motor generator sets have been provided which change the voltage from 220 to 40, at which voltage the various alarms, signals and vault locks are operated throughout the building. The main switchboard, constructed by the Leonard Electric Co., is of black slate and is mounted between two wing walls such that the compartment back of the board is entirely enclosed.

At one end of the engine room and near the switchboard and passageway to the boiler room is the engineer's office. It is provided with glass panels so that the entire engine room is under the observation of those within the office. Within the office are located a gage board, a remote control switchboard and manually operated stations for the engine stop valves. The general appearance of the engine room is greatly improved by the use of glazed tile extending from the floor to the ceiling and by the paneled dark red concrete floor. The lighting fixtures are of the semi-indirect type and they are installed in sufficient number and so arranged that the illumination is very satisfactory. At the opposite end of the engine room from the office is an entrance way that leads to the locker and toilet rooms which have been especially provided for the engine and boiler room crews. Entrance to these rooms may also be had from the boiler room.

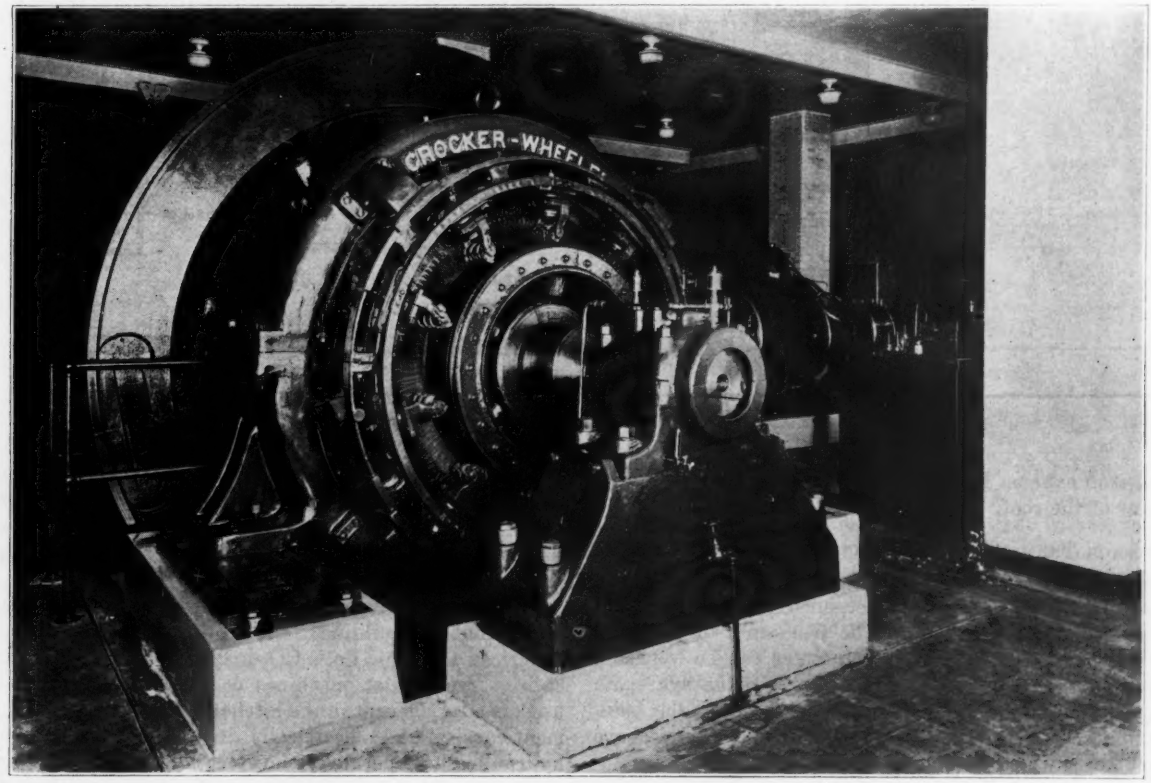


FIG. 5. EACH GENERATOR IS RATED AT 300 KW. AND IS DIRECT CONNECTED TO A UNIFLOW ENGINE

In passing from the engine room to the boiler room, it is necessary to walk through a passageway which extends the entire width of the boiler room. There are located the building pipe shaft, the boiler stack, the boiler feed pumps, the feed water heater, the air compressors and the heating system air valve control board. Exhaust steam from the engines passes through an oil separator and then directly to the low pressure steam riser which distributes heating steam throughout the building. Vanstone joints are used on this riser which is anchored at the base of a concrete pier. A Swartwout

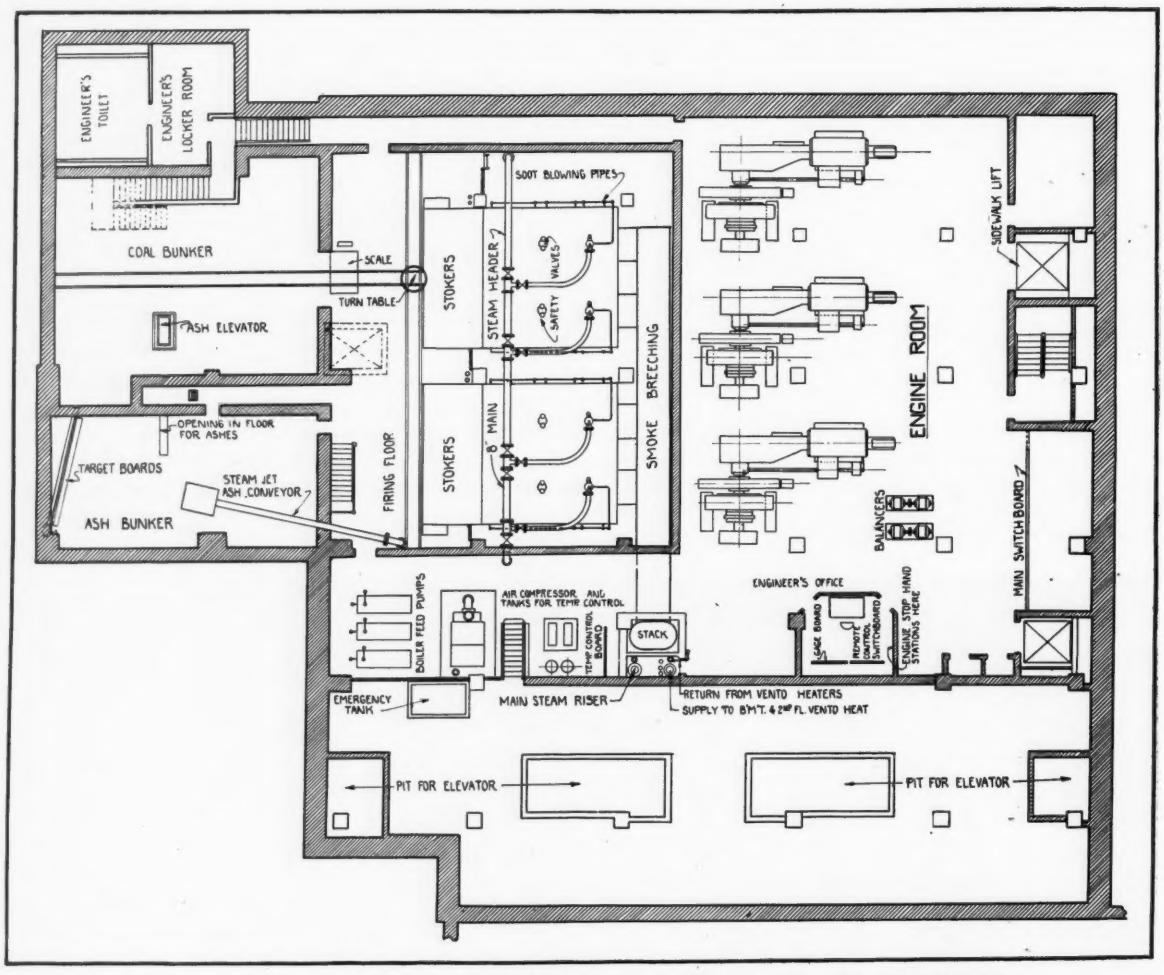


FIG. 6. GENERAL PLAN OF ENGINE ROOM, BOILER ROOM AND COAL AND ASH STORAGE

cast-iron exhaust head has been installed above the high point of the roof.

Storage Tank Saves Duplicate Feed Water Heater

One Cochrane feed water heater and meter has been installed. To provide for emergencies, a tank has been provided so that, should it be necessary to take the heater out of service, all return water can be bypassed to this tank. Five water storage tanks of an aggregate capacity of 125,000 gal. have been placed in the basement; these form a reserve water storage over and above that water which is contained in the roof tanks.

Two 800-gal. Union centrifugal pumps serve the roof tanks. These are driven by Reliance motors and are so piped up that they may be operated either in parallel or in series. This latter piping arrangement practically assures the delivery of water to the roof tanks even though the condition of the pumps might be such that one pump or the two in parallel could not meet the head requirements. The boiler feed pumps consist of three Wilson-Snyder Mfg. Co.'s duplex outside packed plunger pumps, each 10 by 6 by 12 in. The return pumps are two in number and of the motor driven centrifugal type. All sump pumps are installed in duplicate as an assurance of ample capacity and constant service. The suction lines for all pumps are of cast iron, whereas the feed lines between the pumps and the boilers are of brass. Exhaust steam from the pumps is passed through an oil separator and then discharged into the feed water heater.

All drinking water is filtered, cooled and circulated throughout the building. The cooling is effected by two American Carbonic Co.'s CO_2 machines of 8 T. capacity each. Two similar machines cool the brine which is used as a refrigerant in the kitchen. The elevator equipment consists of 14 electrically driven elevators and one hydraulically operated elevator, all of which are equipped with micro-adjustments for bringing them to a stop at an exact level with the floor.

Steam Is Used at Four Pressures

Steam requirements for this building are interesting, due to the fact that four different pressures are used. As previously stated, the main generating units use steam at 180 lb. pressure and the building is heated by exhaust or reduced pressure steam at 2 lb. pressure. In addition there are the requirements of the laundry, which makes use of steam at 40 lb. gage pressure and also the requirements of the kitchen, which uses steam at 25 lb. pressure. The reductions in steam pressure are accomplished by first reducing all steam that is to be used at lower than boiler pressure to 60 lb. through one large reducing valve. The steam at 60 lb. pressure is discharged into a manifold from which three leads are taken off, one for the laundry, one for the kitchen, and one for supplementary steam for heating the building.

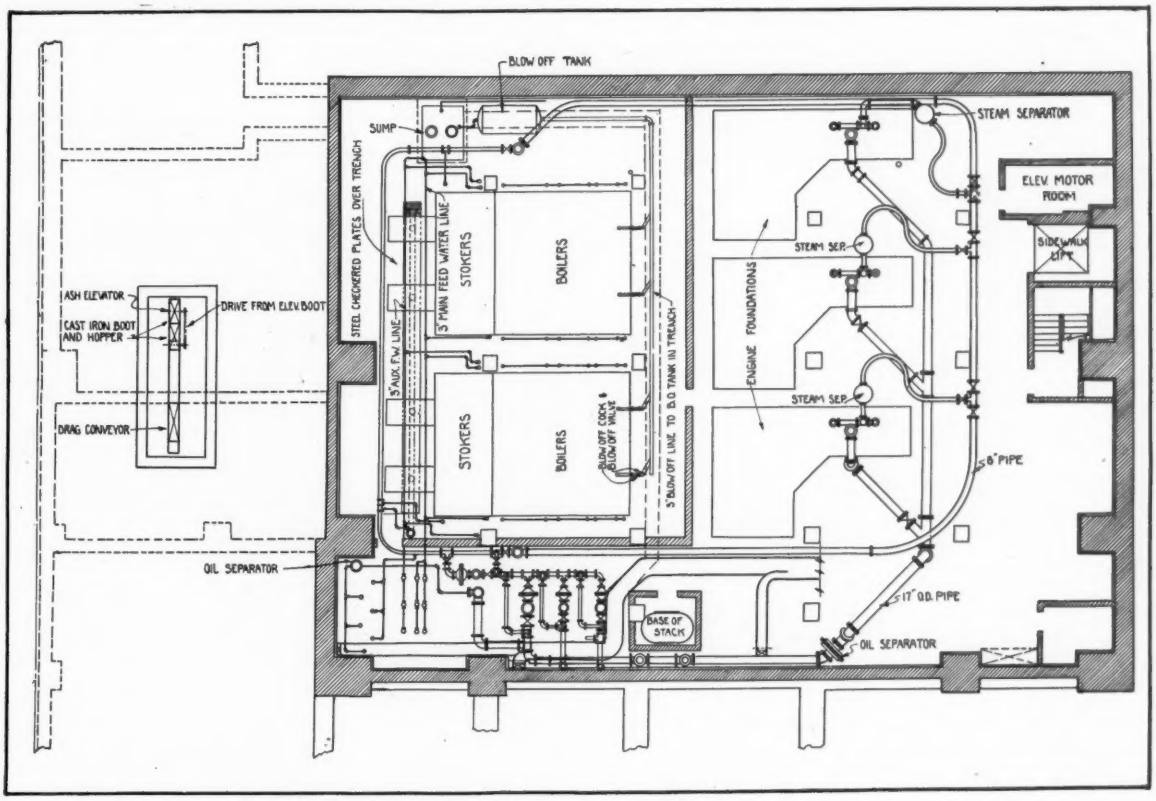


FIG. 7. ALL ENGINE ROOM STEAM PIPING IS BELOW THE LEVEL OF THE FLOOR.

In each of these leads is a reducing valve through which the steam is reduced from 60 lb. to that pressure which the service requires.

Two Operating Floors in Boiler Room

Entrance to the boiler room may be gained from either end of the firing aisle, that is from the passageway where the feed pumps are located or from the passageway which leads to the locker room. The boilers are set low with respect to the engine room such that the top of the stoker hoppers are on a level with the pump and engine room floors. The boiler room floor on this level is covered over with a grating except at stair openings and that space which is occupied by the industrial coal track.

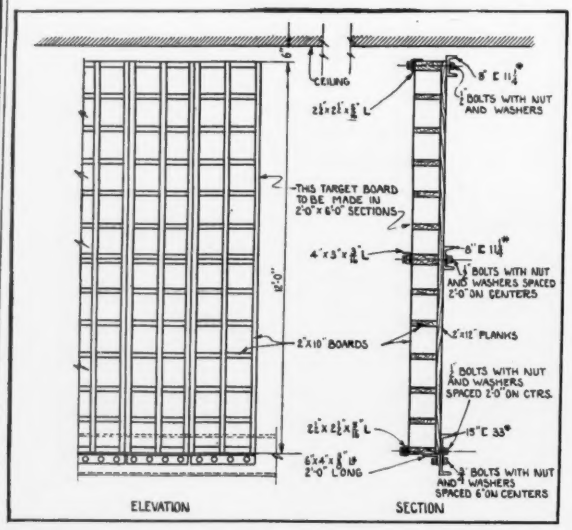
Directly opposite and in front of the boilers are two storage rooms, the floors of which are on the same level as the top of the stoker hoppers. The smaller of these rooms is used for the storage of ash and the larger room is used for the storage of coal. The latter room has a capacity of 800 T. of Ohio coal which will average 13,500 to 14,000 B.t.u. as fired. Coal is dumped directly from trucks into the storage room. As coal is required by the stokers it is loaded into small industrial cars which travel over a track scale located just inside the boiler room wall. A turn-table has been installed so that the cars may be pushed to the proper location for dumping into the stoker hoppers.

Directly below the grating floor is the stoker operating floor. Steel checkered plates cover a trench in which is located a Frederick Engineering Co.'s steam jet ash conveyor. Ash is raked from the pits under the stokers to the conveyor which discharges against a wooden target board in the ash storage room. The target is arranged with fins projecting towards the conveyor end which is about 30 ft. distant. These fins form open spaces in which the ash will pack and so form its own wearing surface. From storage the ash is handled a short distance by hand to a drag conveyor which in turn discharges into an elevator located in the coal storage room. This elevator discharges the ash into trucks at the point of coal unloading, which is in the court directly above the storage rooms. The drag conveyor and elevator were manufactured by C. O. Bartlett and Snow Co.

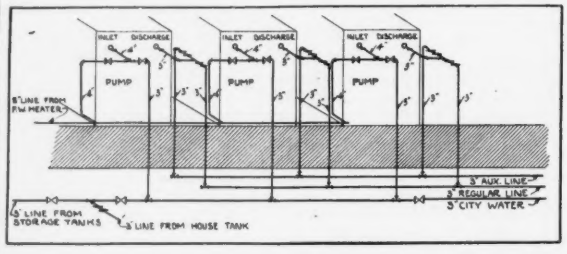
Boilers Are Installed in Batteries

Four longitudinal drum Babcock and Wilcox boilers have been installed. Each boiler is rated at 300 hp. and is designed for 200 lb. working pressure. They are set in two batteries of two boilers each with the front head-

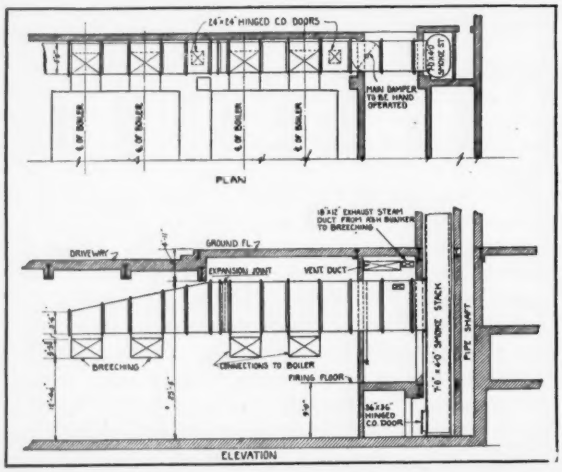
Fig. 8. Some Interesting Details of Important Equipment


CEILING
BOLTS WITH NUT AND WASHERS
THIS TARGET BOARD TO BE MADE IN 2'-0" x 6'-0" SECTIONS
BOLTS WITH NUT AND WASHERS SPACED 2'-0" ON CENTERS
2"x10" BOARDS
2"x12" PLANKS
BOLTS WITH NUT AND WASHERS SPACED 2'-0" ON CTRS.
2'-0" LONG
BOLTS WITH NUT AND WASHERS SPACED 6' ON CENTERS
ELEVATION
SECTION

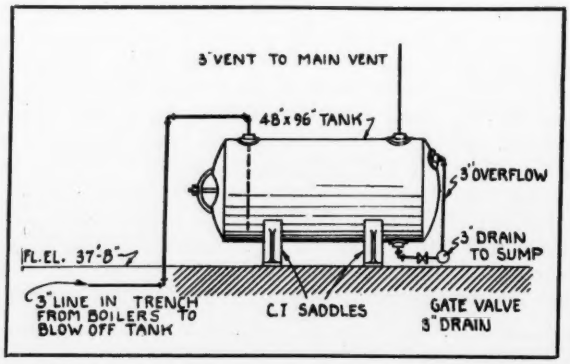
Opposite the end of the steam jet ash conveyor is a wooden target board which is made up in such a manner that the face is a honeycomb of small boxes. The first ash shot against the board will fill these boxes and so stop further wear on the target.



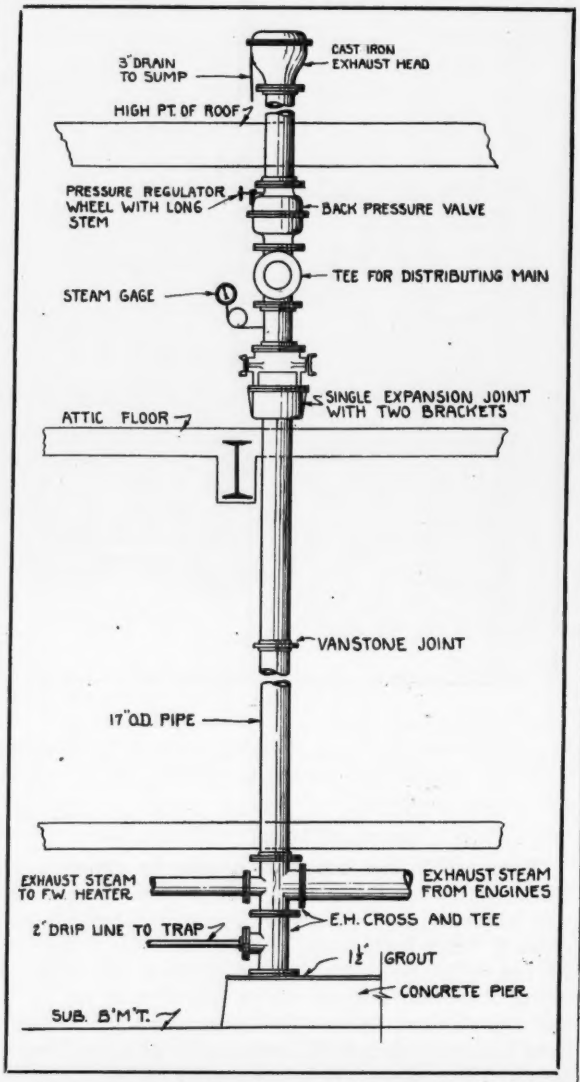
Diagrammatic layout of the piping for the boiler fuel pumps. The pumps may take water either from the city water line or the feed water heater. Two feed lines extend between the pumps and boilers.



Details of the boiler breeching which show connections to the boilers, the expansion joint and the cleanout doors.


3" VENT TO MAIN VENT
48"x96" TANK
3" OVERFLOW
3" DRAIN TO SUMP
FL. EL. 37'-8"
3" LINE IN TRENCH FROM BOILERS TO BLOW OFF TANK
C.I SADDLES
GATE VALVE 3" DRAIN

Above is shown the manner in which the blow-off tank is piped up to the boilers and for drainage.



Low pressure steam is distributed throughout the building from the riser which is here shown in detail.

ers 10 ft. above the floor. Each boiler is served by a Detroit stoker of 65 sq. ft. effective grate area. Two stoker engines have been provided, either of which will drive the four stokers.

Miscellaneous equipment installed with the boilers consists of: Kieley and Mueller, Inc., non-return valves; Diamond Power Specialty Co.'s soot blowers, Hagan Corporation damper control and Mono CO_2 recorders. In addition to this equipment there have also been supplied recorders for flue gas temperature, feed water temperature, steam pressure and steam temperature. Jos. W. Hays Corp. furnished the indicating draft gages.

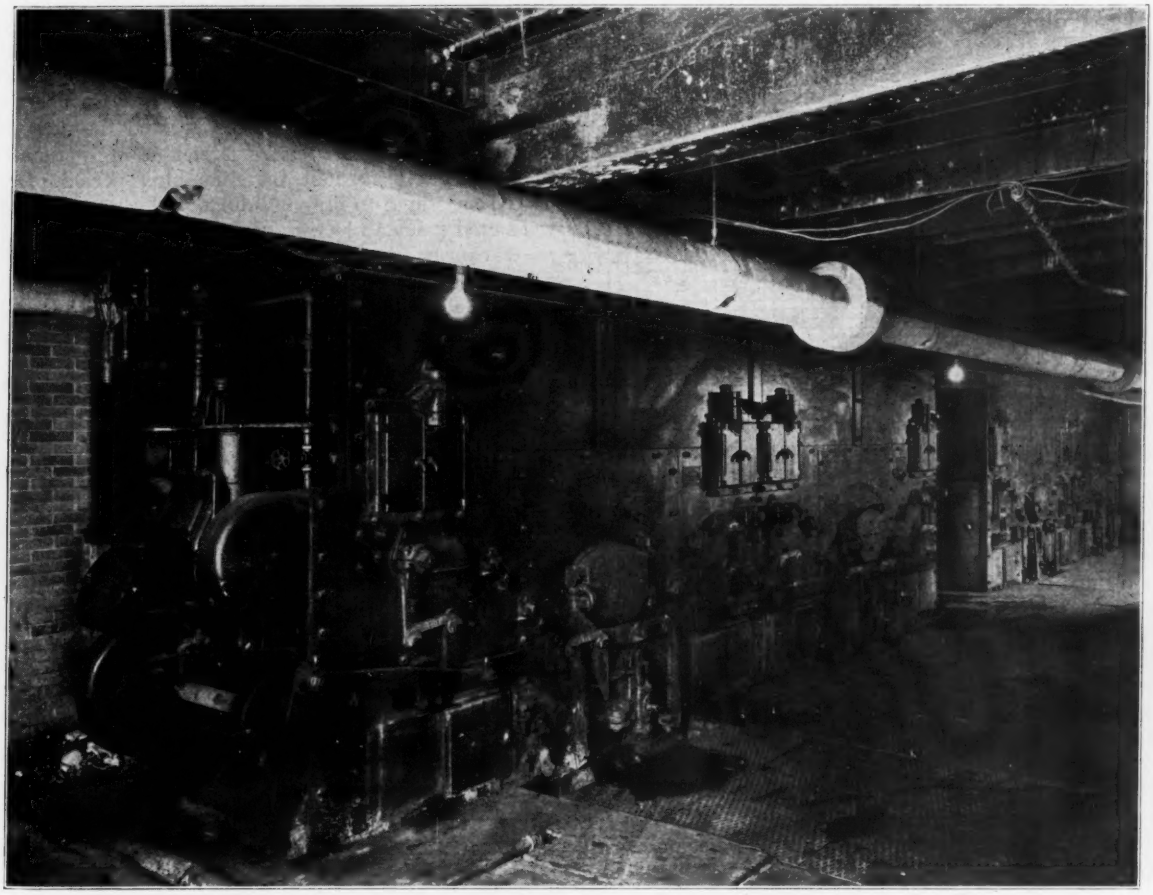


FIG. 9. TWO STOKER ENGINES HAVE BEEN INSTALLED, EITHER ENGINE CAN DRIVE THE FOUR STOKERS

Ample clean out doors have been provided in the breeching and an expansion joint has also been placed between the two batteries. The breeching size at its entrance into the stack is 5 by 8 ft. and the stack is 7 by 4 ft. and of the section as shown in Fig. 7.

Steel Fittings Used for Superheated Steam

As previously stated the main steam header forms a loop through the engine room. This loop also extends through the boiler room. The main piping and bends were furnished by Grinnell Co. The steel fittings were furnished by Kelly and Jones, the reducing valves by the Jenkins Valve Co. and all high pressure valves were manufactured by the Chapman Valve and Manufacturing Co. The high pressure steam lines are insulated with a 2-in. magnesia covering and all other lines are covered with 1 in. of the same material. All traps used throughout the power plant were manufactured by the Strong, Carlisle and Hammond Co.

Heating and ventilation in this building has been given careful consideration. An air washer rated at 29,000 c.f.m. and an exhaust fan rated at 12,500 c.f.m. serve the basement, which includes the engine and boiler rooms. The ground floor is served by an air washer of the same capacity as that which serves the basement. Then for each two floors above the ground floor there will be installed an air washer rated at 55,000 c.f.m. These washers will all be supplied with air from a main shaft which runs up through the center of the building. The air washers were furnished by the Carrier Engineering Co., and all fans were manufactured by the Buffalo Forge Co. The motors used in conjunction with this equipment were furnished by the Reliance Electric and Manufacturing Co.

Walls Used as Plenum Chambers

An interesting feature of the air distribution system of this building is the fact that certain walls and spaces between the ceilings and floors are made use of as plenum chambers. Openings provided around the ceiling lighting fixtures allow the fresh air to escape in the rooms.

Walker and Weeks, of Cleveland, were the architects of this building and Clark, McMullan and Riley, Inc., were the consulting engineers.

Economies of Mechanical Soot Blowers

SAVINGS DUE TO THE USE OF SOOT BLOWERS EXIST ALTHOUGH THEY MAY NOT BE READILY APPARENT DUE TO VARIABLES OF OPERATION. BY ROBERT JUNE

ONE OF THE outstanding virtues of the mechanical soot blower, is that it materially increases over-all boiler efficiency, by reducing the losses in the dry chimney gases. It is a difficult matter, however, to secure reliable data on temperature reductions, effected by the use of mechanical soot blowers. Perhaps the commonest mistake of all is that of endeavoring to gage the effectiveness of soot blowers by the results obtained over short periods. In one plant soot blowers will be credited with saving 7 to 10 per cent. The next plant may show

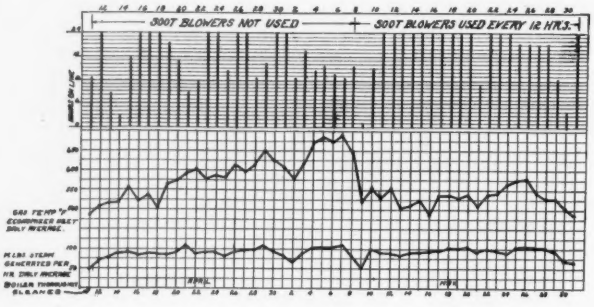


FIG. 1. TEST RESULTS OF A 1000-HP. HORIZONTAL BOILER RUN WITH AND WITHOUT MECHANICAL SOOT BLOWERS

almost no saving at all. A week or two later, if new tests are run the conditions will probably be reversed, with an extremely large saving indicated in the second plant and exceedingly small saving in the first one.

Now soot blower performance is not erratic. The same average savings are effected day in and day out. The trouble lies with the so-called tests, which are necessarily inaccurate, owing to the fact that it is practically impossible to maintain laboratory conditions in the boiler under test.

Inaccuracy is primarily due to the impracticability of maintaining uniformity in the excess air conditions and uniformity in boiler load. Variations in excess air produce wide flue temperature fluctuations and small variations of the CO_2 recorder represent relatively large variations in excess air as for instance, a decrease of CO_2 from 12 to 11 per cent represents an increase in excess air from 54 to 66 per cent with a corresponding fluctuation in flue temperature, which fluctuation may also be interlocked with a fluctuation due to a load variation.

Savings effected by soot blowers cannot be satisfactorily determined by short runs of a few hours, nor can a great deal be gained by examining daily operating charts unless, as stated above, laboratory conditions are maintained. In order to arrive at a satisfactory evaluation of the economies effected, a given boiler should be operated for a considerable period, say of several weeks, with and without soot blowers. Throughout the entire period, effort should be made to maintain uniform boiler output.

To show the fuel savings effected by soot blowers, the results of tests run at a number of representative plants in various parts of the country have been plotted.

TEST AT LARGE CENTRAL STATION

Curves shown in Fig. 1 are the results of a test made recently by a large central station on a modern 1000 hp. horizontal water tube boiler operated at 250 lb. pressure, 200 deg. F. superheat, and at 200 per cent rating, using bituminous coal handled by underfeed stokers. On April 12 the boiler was put on the line with the tubes having first been thoroughly cleaned. From this date until May 8, a period of 26 days the soot blowers were not used and at the end of this 26-day period, flue gas temperatures had risen from 480 deg. F. to 690 deg. F. The first day the soot blowers were operated the average temperature fell 40 deg. and the next day it fell to 530 deg. F. It remained at approximately this average throughout the remaining period of the test, from May 8 to May 30, during which soot blowers were used every 12 hr.

Obviously any equipment which effects such marked reductions in flue gas temperatures is a first-class investment. The fuel saved by reducing the flue gas temperatures may be estimated at 1 per cent for each 20 to 30

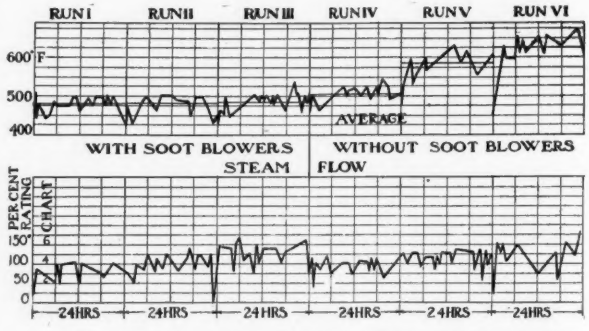


FIG. 2. FLUE GAS TEMPERATURES WITH AND WITHOUT MECHANICAL SOOT BLOWERS

deg. drop in flue gas temperature, depending upon the amount of excess air in the chimney gases.

Results of tests which are shown in Fig. 2 were obtained by a large public utility on a 500 hp. boiler using bituminous coal fed by underfeed stokers. Three runs of 24 hr. each were made with soot blowers operating and three runs of 24 hr. each without operating the soot blowers. The object was to have three runs of each group duplicates of each other in every respect other than the use of soot blowers, and painstaking provisions were made to accomplish this.

Analysis of the flue temperature curves shows a consistent increase in flue temperatures corresponding with the load increase during the three days in which the soot blowers were operated. During the subsequent three days without soot blower operation, the temperature rose from about 485 deg. F. to an average of 625 deg. F. for the last day. The significant feature of this test is the comparison between the third and sixth days. The load was approximately the same during each of these days while the average flue temperature was 140 deg. F. higher as a result of the cessation of the soot blower operation during the two previous days. The

average CO_2 reading for the third and sixth days was 12.4 per cent, under which condition a 140-deg. temperature drop represents a 5.1 per cent saving in carbon burned or a saving of about 4.5 per cent in combustible.

Figure 3 covers the results of a test made in 1921 by the user of a 780 hp. vertical water tube boiler, 225 lb. pressure, 130 deg. F. superheat, oil fired. This test was conducted in an ideal manner for obtaining reliable results. The load variations were, if anything, disadvantageous to the rise in temperature during the non-blowing period as the average load was lower during this period than during the blowing periods. Soot blowers were used once a day for a period of eight days after which the boiler was allowed to go without cleaning for 30 days. It will be noted that as soon as operation of the soot blowers was discontinued, the temperature rose daily from an average of about 545 deg. F. to about 680 deg. F. at the end of the 19th day after which it maintained this same average for the succeeding 11

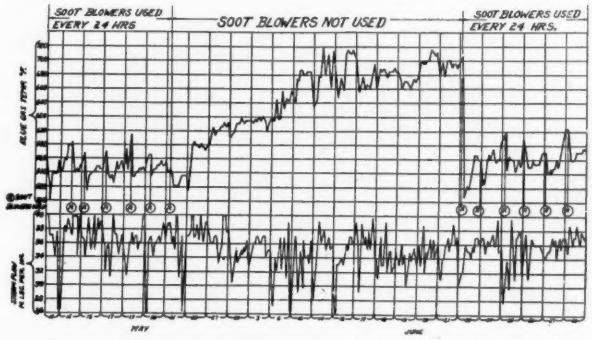


FIG. 3. TESTS WHICH SHOW RESULTS OF MECHANICAL SOOT BLOWING ON AN OIL FIRED BOILER

days. In other words, upon ceasing the operation of the blowers the temperature rose steadily for 19 days through a total of 135 deg. F. subsequently remaining constant, the boiler apparently having become thoroughly sooted.

As mentioned above, it will be noted that during this period the load curve, if anything, decreased, which would indicate a still greater increase in flue temperature at constant load. The remainder of the test confirms the foregoing, since, when at the end of the thirtieth day of the non-blowing period, the boiler being thoroughly sooted, the blowers were again operated, an immediate drop in temperature occurred from 680 deg. F. to an average of 560 deg. F. for the succeeding 8 days during which time the average load corresponds to the first blowing period of 8 days, the average flue temperature being, however, 560 deg. F. as against the original average of 540 deg. F. due to the after-effects of the long 30 days of non-blowing.

Tests shown in Fig. 4 were conducted by a consulting engineer on two duplicate 1000 hp. horizontal water tube boilers, 170 lb. pressure, burning anthracite coal. The two curves represent the flue temperature at various loads for each of the duplicate boilers. The temperature readings were taken at those points on the steam flow charts where the load remained constant for a sufficiently long period to permit the flue gas temperatures to become equally constant. The lower curve covers the performance of boiler No. 1 fitted with valve-in-head soot blowers. Boiler No. 4 covered by the upper curve was hand cleaned once a week by means of an air hose. The points plotted are reasonably consistent and show an average gain of 90 deg. F. in favor of the mechanical soot blowers as compared to the air cleaning. The soot blowers were operated once every 8 hr. A 90 deg. F. decrease in flue temperature at say 12 per cent CO_2 represents a saving of 3.5 per cent in carbon or about 3.1 per cent in combustible.

Fuel Saving Corresponding to Flue Gas Temperature Reductions

The following table may be used to estimate the fuel saved as a result of reduced flue gas temperatures. Column 3 is based on the combustible containing 75 per cent carbon and should be corrected in the case of fuels where the carbon in combustible varies appreciably from the above figure.

SAVINGS EFFECTED THROUGH REDUCTION OF FLUE GAS TEMPERATURES

Per cent of CO_2	Per cent of excess air	Per cent combustible saved for each 100 deg. F. reduction
8	117	5.1
9	97	4.6
10	81	4.1
11	60	3.7
12	54	3.5
13	44	3.3
14	35	3.1

Five essentials are involved in the prevention of soot waste. These are:

1. Frequency of cleaning in order to minimize the cumulative effects of increasing deposits.
2. Thoroughness of cleaning in order to maintain high furnace and boiler efficiency, and prevent the destructive corrosive effects of soot accumulation.
3. Availability of system: the soot cleaner should be instantly available, and capable of rapid operation.
4. Durability of system: The blower units should be so designed and constructed that they will withstand the stress of hard service without necessity for frequent repair or replacement.
5. Economy of operation: The soot removing system should be cheaper in operation than hand blowing; it should be so installed as to prevent the entrance of cold air into the furnace during its operation. It should not interfere with the operation of the boiler and it should pay for itself from an investment standpoint.

Comparative Costs of Soot Blowing

The following is a comparison between blowing a boiler by the hand lance method and by mechanical soot blowers of both the independent valve type and the valve-in-head type. A 500 hp. boiler is assumed, 200 lb. steam pressure, operating at 175 per cent rating, on a basis of the boiler being operated 300 days of 20 hr. each per day, with an evaporation 8 lb., and a coal cost of $5.50 per T. fired under the boiler. The figures are based on the boiler being blown twice a day with mechanical soot blowers as against once a day with hand lance.

Cost of steam is based on each soot blower valve being open a total of 60 sec. each time the boiler is blown in the case of the independent valve blower and 30 sec.

in the case of the valve-in-head blower. A 500 hp. horizontal water tube boiler has approximately 40 hand lance openings in the dusting doors on each side. Based on a steam flow of 30 sec. while the lance is in each dusting hole, the steam consumed, based on Napier's formula for steam flow through a ¾-in. nozzle, results in a total of 2880 lb. for blowing both sides of the boiler. In cases where the boiler is only blown from one side, allowance in the above figure should be made. It is to be noted, however, that a longer blower interval should be allowed and that hand lance cleaning becomes less effective as the boiler width increases, being virtually impractical in some of the larger boilers. The cost of steam in both cases is based on 8 lb. evaporation with coal at $5.50 per T. fired.

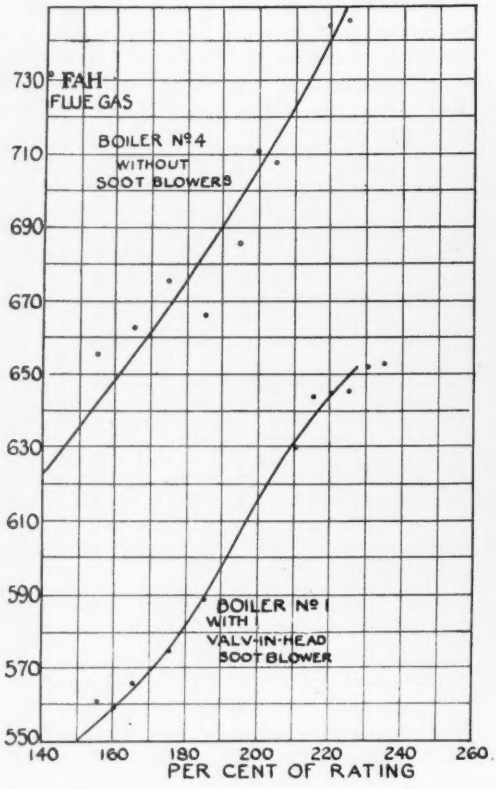


FIG. 4. PARALLEL TESTS OF TWO 1000-HP. ANTHRACITE FIRED BOILERS

Labor cost is based on 40c an hr. and on 15 min. each time the boiler is blown in the case of independent valve type blowers and 9 min. in the case of valve-in-head type blowers. The time consumed in blowing a boiler by hand lance is largely dependent upon the method for gaining access to the dusting holes, such as the time consumed in moving the ladder, scaffolding, or other means which may be used. It is also dependent upon whether the cleaning operation is carried on from one or both sides. It is assumed that the time would probably run from 1 to 1¼ hr. per side and the figures are based on 2 hr. for blowing both sides.

In cases where the boilers are cleaned only when shut down, the economic loss due to their being off the line should be considered. This same factor should be considered where inability to effect satisfactory hand cleaning, such as in large width boilers, necessitates their being taken off the line periodically. The thoroughness with which it is practical in actual daily operation to clean boilers by the hand lance, particularly in the case of modern wide boilers, should be recognized in estimating the reduction in flue temperature effected by the use of mechanical soot blowers.

Cost of the mechanical soot blowing equipment would be $660.00 for the independent valve type and $740.00 for the valve-in-head.

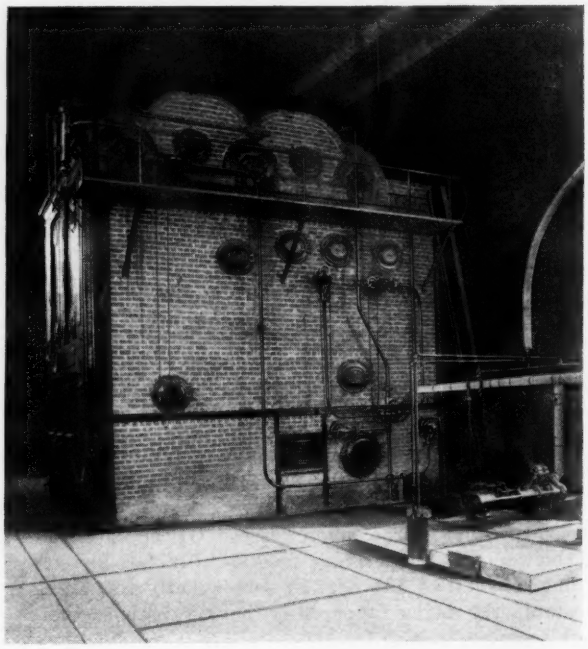


FIG. 5. SHOWING INSTALLATION OF MECHANICAL SOOT BLOWERS ON A STIRLING BOILER

OPERATING COST PER YEAR WITH HAND LANCE

Steam	$300.00
Labor (2 hr. per day)	240.00
Maintenance	25.00
	$565.00

OPERATING COST PER YEAR WITH MECHANICAL SOOT BLOWERS

	Independent valve type	Valve-in-head type
Labor	$ 60.00	$ 36.00
Steam	184.00	92.00
Interest @ 6%	40.00	45.00
Depreciation and Maintenance, 20%	132.00	148.00
	$416.00	$321.00
Decrease in operating cost due to mechanical blowers	$149.00	$244.00

Operation of a boiler under the conditions named would consume about 10,500 T. of coal in a year's time. Figured at $5.50 per T., this would amount to $57,700 per year.

1 per cent saving in fuel would amount to $ 577
2 per cent saving in fuel would amount to $1150
3 per cent saving in fuel would amount to $1730
4 per cent saving in fuel would amount to $2310
5 per cent saving in fuel would amount to $2885
6 per cent saving in fuel would amount to $3460

Tests have demonstrated that savings in fuel run from 2 to 8 per cent. Assuming the figure of 2 per cent, we would have a saving in fuel of $1150. After all charges have been written off in connection with the mechanical soot blowing equipment, it shows a net return of $1299 per year on the original investment of $660 in the case of the independent valve blower, and $1394 a year on the original investment of $740 on the valve-in-head blower.

Boiler Troubles from the Operating Man's Standpoint*

By Carl J. Smith†

IN THIS article, it is intended to deal with troubles encountered in the operation and maintenance of steel mill boilers as, no doubt, the troubles encountered in the operation of this class of boilers are more numerous than with boilers in any other service, due to the absence of any well defined load curve, the absence of any considerable amount of condensate return and a large labor turnover in the operating forces.

Troubles of a steel mill operating engineer may be separated into three classes, viz.: First, those due to faulty design and construction of the boiler plant; second, those due to the operators and their method of operation; third, all troubles which are not due to faulty design or faulty operation, but are incidental to the operation of boilers in this class of service.

In discussing the list of troubles, as viewed by the average boiler-house operating engineer, the most common of them all is "low steam." As originating in the boiler-house, strictly speaking, "low steam" is not a trouble, but rather the effect of trouble. If all the other troubles of the boiler-house were eliminated, "low steam" would also be eliminated as far as the boiler-house is concerned. "Low steam" is caused quite as often by troubles outside the boiler-house, such as broken or worn piston rings, worn engine cylinders, engine valves out of adjustment, low vacuum on condensers, leaky steam traps, promiscuous use of electric heaters, rolling cold steel, etc. As the mill production depends on having good steam pressure always available, the boiler-house operating engineer quickly realizes that he is in serious trouble if the pressure drops below the minimum point, which is called good steam, for the mill in question. The seriousness of the trouble is magnified by the fact that when the steam pressure is low, in some mysterious way, the mills do not have any breakdowns, delays, or defective product which is not generally attributed to the "low steam."

In the ordinary steel mill, as the mill production depends on good steam pressure, the first rule is: Keep the steam pressure up, and the second: Go after economy. Under these conditions, the boiler-house operating engineer, in order to escape the dire result of his boiler-house troubles, must be on his toes, pick his troubles young, and overcome them before they multiply.

One of the most common boiler troubles and one which causes serious loss in capacity and economy, is leaky boiler settings. To maintain settings approximately tight requires the constant attention of the operating force and the results obtained repay many times over the cost of all the attention given it. The application of a complete covering of the settings with one of the well-known plastic boiler coatings will eliminate most of the air infiltration and labor required to keep the settings tight.

Leaky baffles, causing short-circuiting of gases through the boilers, are a source of much loss in efficiency and economy, and boiler baffles should receive the careful attention of the operating force. Every time a boiler is taken off for cleaning and repairs the baffles should be carefully inspected, pointed up, and made tight.

Soot and ash accumulation should be blown off the heating surfaces of the boilers at least twice in every 24 hr., as this dirt acts as a heat insulator and if allowed to remain causes a heavy loss. Ninety per cent of this work can be handled with mechanical soot blowers to better advantage than with a hand lance and the use of mechanical soot blowers does away with most of the drudgery of blowing flues. They also show a considerable saving in steam and labor.

Slow ignition is a trouble often met with on natural draft traveling grates. This trouble is generally experienced with old style low settings and its elimination is purely a question of locating the ignition arches so as to get a high localized temperature at the point of ignition. The use of properly designed flat arches is a great help in curing ignition troubles and lowering arch expense.

Refractory Troubles

Furnace refractory troubles are generally caused by a poor grade of fire brick, poor bonding material, poor workmanship, or poor design of brickwork. In the combustion chambers the best grades of fire brick are the cheapest. As good brick will not stand up with a poor bond, it will be found a paying investment to use special high temperature cement at least on the inner course of the furnace walls. If fire clay is used, care should be taken that the best grade of clay is used. Good material and good workmanship with thin joints will insure long life. In designing boiler settings it will be found that laying up the furnace walls with solid fire brick and eliminating the common brick backing will be economy in the long run and be good insurance against brickwork trouble. The difference in expansion between fire brick and the common brick causes the walls to crack and loosen up. This is especially true with high furnace temperatures on boilers working at high ratings and on boilers carrying extremely variable loads. It will be found that if the furnace brickwork is followed up and patched when needed with a mixture of high temperature cement and ganister, the life of the furnace will be lengthened considerably.

*Paper delivered at the Annual Convention of Iron and Steel Electrical Engineers at Buffalo, Sept. 24-28.

†Fuel Engineer, Inland Steel Co.

Bad boiler feed water causes much boiler trouble from scale and mud. The installation of water softeners eliminates most of this trouble when operated correctly; however, the use of treated water necessitates frequent blowing down of the boilers to keep the concentration of soluble salts down below the point where trouble with foaming is encountered. Where raw water is used for boiler feed, the mud and scale must be cleaned out of the boilers at regular intervals or else the efficiency and capacity of the boiler-house will quickly start dropping. The wise boiler-house operating engineer will establish the best cleaning schedule for his boilers and will let nothing interfere with maintaining this schedule. The boiler-washers and boiler washing equipment are one of the most important branches of the average boiler-house and if they are neglected trouble quickly comes in the shape of burned tubes, low efficiency and capacity, and a long hard fight to get the boilers back in shape.

Often, after a considerable period of dry weather, trouble will be experienced with natural draft chain grates on account of the capacity dropping off. This may be blamed on poor coal, whereas it really is caused by the coal being too dry. Adding enough water to the coal to bring the moisture contents up to 10 or 12 per cent will cure this trouble and materially decrease the amount of droppage through the grates. It has been our experience that the best place to add the water is in the storage bins and not in the stoker hoppers as it requires considerable time for the coal to become uniformly moistened.

Feed Water Regulators

Feed water regulators often cause considerable trouble on account of not controlling the feed properly. A great deal of this is caused by not carrying a steady excess pressure on the feed water over the boiler pressure. When centrifugal boiler feed pumps are used, this surging of the feed water pressure, caused by a sluggish pump governor, is the cause of the major part of the feed pump troubles as well as the feed water regulator troubles. Most of the feed water delivery troubles can be eliminated by the use of a sensitive accurate differential pump governor on the boiler feed pumps.

In some plants where two or more feed water heaters are operated in parallel, trouble is experienced in dividing the load equally between the heaters. It is almost impossible to do this with individual float control on each heater, but the trouble can be cured by using a common float box, connected to each heater, to control the total feed to a dividing box with wiers to proportion the water to each heater.

A careful analysis of all the troubles of steel mill boiler plants will show that 90 per cent of the troubles are maintenance troubles rather than operating troubles. It is impossible to have an efficient, smoothly working boiler plant if the equipment is in poor condition. A good boiler-house foreman must be, in every sense of the word, an expert on maintenance work. He should carry the necessary spare parts and watch carefully every piece of equipment to see that it is properly handled and endeavor to spot trouble before it actually materializes. In this way he generally can sidestep trouble and avoid expensive delays and repairs. The difference between a good foreman and a bad one is that the good man spends the major portion of his time correcting the causes of trouble, whereas the bad foreman is busy correcting the effects of trouble. The boiler-house foreman, besides being an expert on maintenance, must thoroughly understand the principles of economical operation and see that they are practiced by his operating force. He should have at least instruments enough to tell him what load his boilers are carrying and to ascertain thereby, in case of "low steam," whether the cause is in the boiler-house or in some of the mills.

All steam and hot water lines around the boiler-house should be kept tight and all steam traps in good condition as a multitude of small leaks sum up to a serious drain on the boiler-house output. The boiler-house foreman should keep a boiler-house log book in which a record is kept of all repairs made and everything out of the ordinary which takes place in the boiler-house. This record will be invaluable as a reference in following up his work.

Fire Clay Mortar for Furnaces

By Claude C. Brown

ANY MORTAR made up of nothing but pure fireclay a very poor mortar which has but little holding or binding power and practically no rigidity of structure after it has been heated. Many times the brickwork of a furnace will be laid up with mortar made in this manner and when it is first put in it looks satisfactory, but after it has been in service for several months it becomes crumbly and is of absolutely no value as a binder for the brick.

When mixing fire clay mortar, the proper method to use is to mix the fire clay with a quantity of crushed firebrick. Anyone who has not tried this will be astonished at the results. Cases have come to the attention of the writer where joints were made up between firebrick in furnace work that was practically as good after 3 mo. of hard usage withstanding the erosion of an oil flame, as the day it was installed. It seems that the crushed firebrick and the fire clay have an affinity for one another under conditions of high heat, and fuse together to form a solid joint.

It has been found that for laying up 1000 fire brick the proper quantity of fire clay to use is ½ T. of fire clay mixed with ½ T. of crushed fire brick. This crushed fire brick should contain some powdered dust, some fine grain and the remainder should consist of granules about the size of large wheat.

Recent tests made upon experimental settings composed of fire brick laid up with mortars containing different proportions of crushed fire brick mixed with the fire clay, show decisively the value of such a mixture. The following table illustrates the results obtained in a number of these tests:

Percentage fire clay	Percentage crushed fire brick	Fusion point Deg. F.
100	0	3150
75	25	3171
50	50	3183
25	75	3206

Fire clay and fire brick in storage should be protected from the weather for the reason that such exposure tends to set up a rapid deterioration which greatly depreciates the refractory value of the material.

Recovering Fuel from Boiler Ash and Clinker

High Price of Fuel in Europe Gives Impetus to Many Novel Schemes of Recovering Fuel from Refuse. By C. H. S. Tupholme

TO THE MAJORITY of power house engineers and fuel technologists the term "fuel economy" generally conveys the impression of burning fuel more efficiently, by the employment of correctly-designed furnaces, and attention to draft regulation, fuel firing and

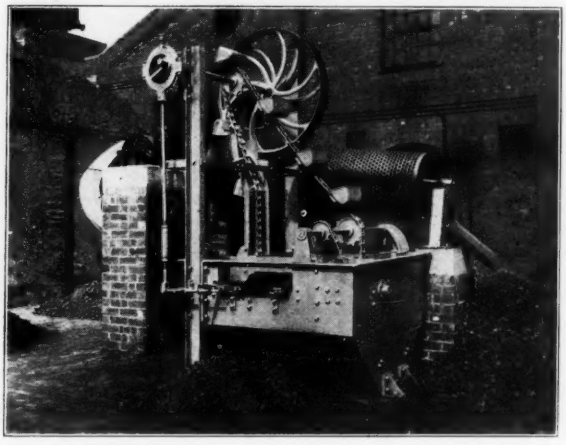


FIG. 1. A TYPICAL INSTALLATION OF THE WALLER WASHER

fuel bed thickness. Vital though these considerations are, there is another aspect of fuel conservation which is only too often overlooked; that is the recovery of combustible matter from ash and clinker normally discharged as worthless. Considerable success in this direction has already been achieved in Great Britain and there are now available a number of separators and fuel recovery machines which have proved well worth their initial outlay. Not only tests, but everyday operation, have shown astonishing results in separating combustible material from real waste.

There is no doubt that in all industrial plants the enormous quantity of valuable combustible matter present in the ashes and clinker discharged from boilers is a source of waste seldom fully realized. In the ashes removed from boiler furnaces, the proportion of combustibles approaches 20 per cent, equivalent to a loss of about 3 to 5 per cent of the original fuel employed. Obviously here is a direction in which a definite contribution to the conservation of fuel can be made.

For the recovery of fuel from ash, two systems have been developed in Europe, (1) Physical, (2) Electrical. In Great Britain, attention has been paid chiefly to the physical methods of recovery. In Europe, considerable progress has been made with other methods.

These processes make use of the fact that when two solids, the one heavy and the other light, are mixed, their separation may be effected by immersion in water, when the heavier will sink more rapidly than the lighter; or, if one substance be lighter than water, then this will float on the surface while the heavier will sink to the bottom. Coke is heavier than water, but owing to its porosity, its apparent specific gravity is nearly identical with that of water, with the result that until it becomes saturated it sinks slowly.

Regarding the specific gravities of the substances in the mixture, considerable variation is found, but the average of a number of tests shows the following:

Clinker	2.05
Shale	2.50
Coke	1.25

In each of these separating methods, the breeze is screened out from the material before it is passed on to the separating apparatus proper. The systems usually employed in Britain operate on the flotation principle. One of these is the froth-flotation method. The principle of operation here is as follows:

When certain reagents are added in small quantities to water, and the whole is agitated violently, a large number of minute air bubbles are formed. On allowing

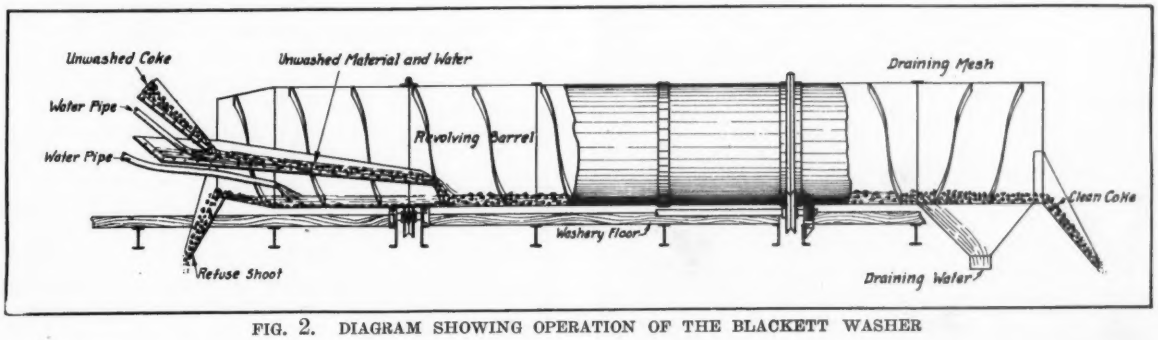


FIG. 2. DIAGRAM SHOWING OPERATION OF THE BLACKETT WASHER

the liquid to stand, the bubbles do not coalesce, but remain separated from each other and rise slowly to the surface, where a more or less permanent froth is formed. The reagents which may be used for this purpose are many and various, and include certain oils such as turpentine, soluble organic substances such as cresol, certain alcohols like amylalcohol, and various soaps. The proportion of reagent to the material treated is small, amounting in most cases to a fraction of a pound of the reagent to a ton of water.

If solid particles are suspended in the water, these particles may or may not becomes attached to the bubbles. If they do become attached, on allowing the liquid to stand, the bubbles rise to the surface and form an extremely stable froth, by which the solid particles are supported.

Particles of coal can readily be floated by this method, while on the other hand ash and earthy substances will not be floated. It follows then that coal may be separated from its incombustible constituents.

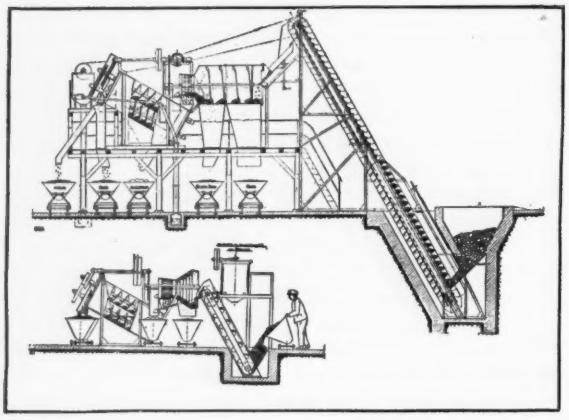


FIG. 3. A LARGE (TOP) AND SMALL (BOTTOM) COLUMBUS WASHER

This froth-flotation method has already demonstrated its efficiency as a separator of combustibles and incombustibles.

THE WALLER WASHER

One of the most successful washers is that known as the Waller, which is shown in Fig. 1. In this type, water is oscillated by compressed air, and the screen

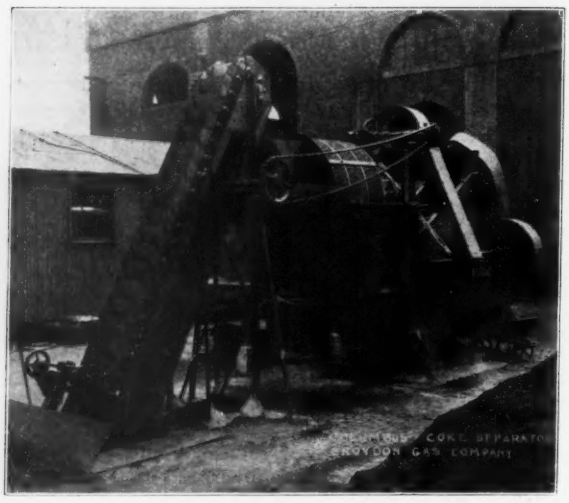


FIG. 4. A COLUMBUS INSTALLATION

plate upon which the material is deposited is also oscillated by eccentrics from which the plate is suspended; and so arranged that, with the downward motion of the plate, water is forced upwards through the bed of coke and ash. This action separates the coke from waste, the coke being carried forward by the stream of water, while the clinker and ash remains on the screen plate or falls through the holes to the bottom of the tank.

Another machine, known as the Blackett washer, as will be seen from Fig. 2, consists of a cylinder to the interior periphery of which is attached a coil made in the form of an Archimedean screw. The cylinder is at a slight incline, the inlet being at the higher end, and rotates at a speed of about 9 r.p.m. The screw is arranged to operate in opposition to the incline, so that a heavy material like clinker, thrown in at either end, is taken up by the screw and discharged at the higher end.

When the Blackett machine is operating the cylinder is rotated by friction gear, while at the same time a stream of water is injected at the upper end. The water, flowing over each successive weir formed by the

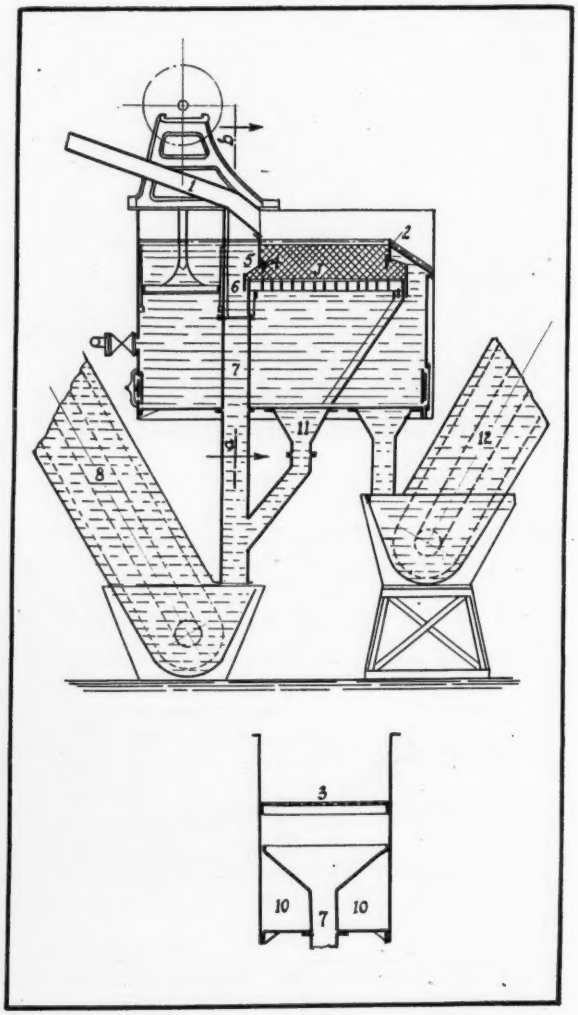


FIG. 5. TYPE OF SEPARATOR DEVELOPED IN BELGIUM

screw, runs away at the lower end. The coke floats on the surface of the water, flows over the weirs, and is discharged at the lower end of the cylinder. The heavy clinker sinks to the bottom and is conveyed by the screw to the higher end of the cylinder, where it also is discharged. In this way clinker and coke, or shale and coke, are separated.

Figures 3 and 4 will readily assist engineers to comprehend the simple principle upon which the Columbus separator operates. The machine consists essentially of two main sections; a revolving drum sieve, into which the waste material is fed, either by hand in small machines or by continuous conveyor in the larger types, and the separator proper. The process is, briefly, as

follows. The material passes through a revolving mesh sieve drum, which rejects the fine dust, and through a revolving large-mesh grid, which ejects any occasional oversize lumps of slag, the elimination of which experience has proved to be desirable, as they consist mainly of pure slag of no calorific value. From the grid the material drops into the separator chamber, consisting of an inclined sheet-iron container within which revolves, in separate chambers, two super-imposed conveyor-worms.

This container is half-full of water, the specific gravity of which has been increased to about 25 deg. or 30 deg. Baumé, by any of the numerous means readily available, such as, for instance, by admixture of common clay, loam, chalk, carbide-slime, salt-lye or any similar suitable substance. Upon falling into this liquid the heavy slag immediately sinks to the bottom, while the

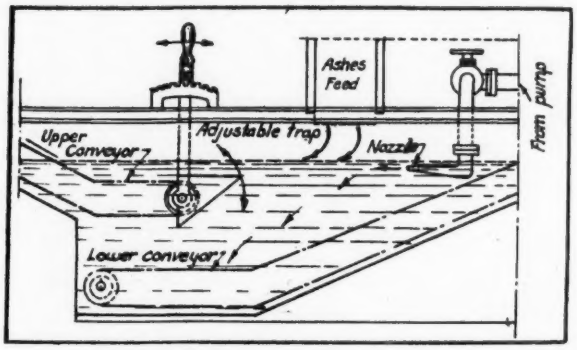


FIG. 6. IN THIS MACHINE THE SEPARATION TAKES PLACE DIRECTLY ON THE SURFACE OF THE WATER

lighter coke floats on the surface. The upper conveyor-worm, which projects well into the liquid but does not reach the bottom of the tank, picks up the coke only and conveys it to its chute. The lower conveyor-worm, on the other hand, is carried down to the tank bottom, picks up the slag and stones only and passes them out through a separate chute. Tip wagons, into which the separate coke and slag fall, are usually placed directly underneath these chutes. Large installations are generally arranged to feed the separated materials into railway wagons or into bunkers either directly by mounting the apparatus on a raised platform or by means of conveyors.

Only little power is required by the separator, i. e., from 1 to 4 hp., according to size and output. The water consumption is only about 20 to 50 gal. per hr. and almost any waste water, fresh or salt, can be used.

Both the coke and the slag are immediately available for use; the coke, having become only superficially moistened, can at once be re-fed into the furnace. The slag is frequently used for the manufacture of slag-bricks, after being crushed and mixed with a small proportion of sand and cement. These bricks are easy to make, are inexpensive and, requiring no firing, can be prepared on the actual site on which they are required. The Columbus separator is made in three stock sizes:

Type A, yielding 2 cu. yd. per hr. Power required, 1—1½ hp.

Type B, yielding 4 cu. yd. per hr. Power required, 2 hp.

Type C, yielding 8—10 cu. yd. per hr. Power required, 3—4 hp.

One unskilled laborer only is required to attend the machine, even for the largest type. In big installations additional labor is, however, required to transport the material to and from the machine, or elevators and conveyors can be arranged for this purpose. Types A and B can be mounted on a trolley, so that they may be moved from place to place or up to the existing slag

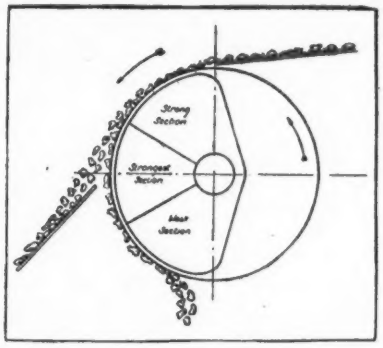


FIG. 7. SECTION ILLUSTRATING THE PRINCIPLE OF THE MAGNETIC SEPARATOR

heap. The standard machine is supplied with an overhead shaft with fast and loose pulley for belt-drive from any convenient shafting. When required, independent drive by a small electric motor or petrol engine, fitted inside the base of the machine, is arranged for. In this case, a small counter-shaft is fitted to a bracket on the side of the machine.

Typical operating data of the Columbus washer are shown in the accompanying table:

Type	Motor Power	Weight of Breeze Treated	Weight of Coke Recovered	Weight of Fine Ashes Recovered	Weight of Clinker Recovered	Difference in Weight in and out Machine = Water and Clay
		T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.	T. C. Q.
"C"	6 H.P.	24 8 1	11 18 1 = 45.68 per cent	8 8 1 = 32.24 per cent.	5 14 1 = 21.87 per cent.	1 12 2 = 6.14 per cent.
"C"	6 H.P.	17 11 1	7 14 0 = 41.72 per cent.	6 5 0 = 33.87 per cent.	4 10 1 = 24.45 per cent.	18 0 = 4.87 per cent.

Belgian Washer Employs Pulsating Piston

In Belgium there has been developed recently a separator of the pulsating piston type, in which a single screen is spaced away from both the front and rear walls of the body of the washer; and its object is to introduce into these washers improvements, for the purpose of securing the regular discharge of the lighter pieces or stones (for re-washing) at the front of the screen, and a regular delivery of the finished products. The washer is also designed to insure uniform working and output of the plant irrespective of the rate of feed of the material to be washed.

These desiderata are obtained by providing at each end of the screen, a slide of adjustable height. The heaviest stones are discharged automatically at the side near the pulsating plunger; the lighter stones are discharged similarly at the other side of the screen. These two classes of stones form a barrier in front of each of the slides and pass into separate compartments filled

with water to the same level as that of the water in the screen compartment so that the washer will never run dry. The finished material is discharged over the barrier of lighter stones. A washer of this type is shown in Fig. 5.

As may be noted, the trough of the washer is fed by means of the chute 1, situated above the piston chamber,

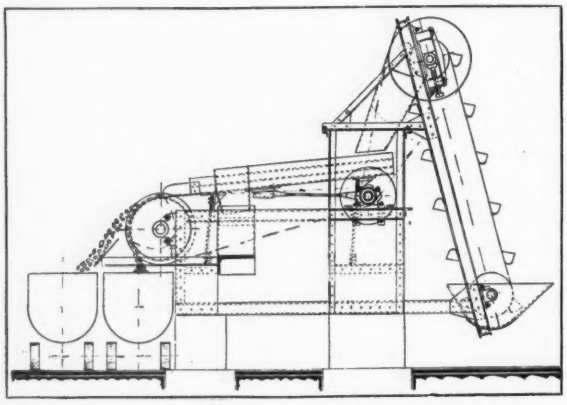


FIG. 8. COMPLETE DIAGRAM OF THE KRUPP MAGNETIC SEPARATOR

which delivers the materials to be washed onto the washing bed supported by the screen. Communication between the piston chamber and the screen is effected by of a bucket elevator, 8. The heavy stones (final stones) being thus discharged on entering the washer, the following conditions are established for the latter:

(1) A more homogeneous washing bed
(2) A more uniform water-stroke
(3) An improved yield.

Since the slides extend across the full width of the washer, there is no longer a risk of the washer becoming obstructed by the presence of a foreign body. The screenings, i.e., the material passing through the screen, 3, are discharged at the bottom of the washer by way of the pipe connection, 9. The lightest stones (for rewashing) are discharged at the front end of the screen by means of a slide, identical with that at the rear end, and by the pipe, 11, and a bucket elevator, 12.

Since the produces are discharged into separate compartments also filled with water to the same level, the washer cannot be emptied of water as in the case of certain other washers.

An interesting German method is that in which the water bath is kept under pressure and in constant motion. The feature of the process is the addition to the water bath of some sand mixed with cement. The porous coke absorbs little of this mixture, but the coarser pores of the clinker fill up completely with the sand-cement mass, their weight being in consequence considerably increased. The separation of clinker and coke is then readily accomplished by deposition or centrifuging.

FIG. 9. A LARGE COULSON PLANT FOR SEPARATING COMBUSTIBLE MATTER FROM ASH INSTALLED AT A LONDON PLANT

the openings 10. The discharge of the coal is effected automatically by the adjustable sill, 2, which is of approximately inverted V-shape with one branch vertical and the height of which can be controlled for varying the thickness of the bed of coal.

Heaviest stones are separated immediately at the rear end of the screen and pass away under the adjustable slide 4. They form, in front of the lip, 6, a barrier the height of which is determined by that of the said slide.

Each fresh stone arriving at 5, should drive out another at the top, and this latter stone drops into the funnel-shaped pipe 7, whence it is discharged by means

The Weber Washer

An apparatus recently introduced is illustrated in Fig. 6 from which the principle will be easily understood. The separation of the combustible matter from ashes and clinker takes place directly upon the surface of the water before the coke has had time to absorb the latter. This result is obtained by producing upon the water a surface current which draws the lighter material along with it and permits the heavier material to sink, the curves of movement of the two materials being widely separated. The separation is facilitated by a trap, which is mounted horizontally in the current produced by the nozzle-injector, the coke or the other light

material falling from the trap upon an upper band-conveyor, while the clinker and heavier material fall upon a lower-band-conveyor.

Magnetic Process Used in Germany

The magnetic process, developed largely in Germany, operates on the principle that all kinds of coal incorporate iron in the form of pyrites. Pyrites has no magnetic properties, but when the coal is burnt the pyrites is converted into oxides of iron which are magnetic. Thus in the burned fuel the combustibles are non-magnetic and the non-combustible are magnetic.

In the Krupp magnetic process, the ash is fed onto a brass drum rotating about a horizontal axis, and is exposed to the action of a stationary magnetic field, the strength of which increases from the top of the drum downwards, afterwards decreasing to its least strength in the lower section of the drum (see Fig. 7). The screened ashes are fed onto the periphery of the drum, so that the ash constituents containing the iron are held magnetically to the surface for a portion of a revolution, and then fall off into a separate receptacle as they pass out of the magnetic field. The coal or coke does not adhere to the drum, but leaves its surface directly after contact with it and is projected into its own receptacle. It is claimed that lumps of ash and clinker up to 3-in. mesh will adhere to the drum and be removed. The power required varies from 0.6 to 2.4 kw.-hr. per ton of ashes treated. A complete installation of this system is shown in Fig. 8.

An advantage of the electro-magnetic process is the fact that all the combustible matter is recovered in the dry state; thus its value as a fuel is not impaired by a heavy percentage of water.

One Year in Near Perdition

Experiences of an Engineer Who Spent One Year at a Prison Plant. By A. R. Knapp

PROBABLY NOT many engineers have had the opportunity of prison work. To those who have, I offer my hand in brotherly sympathy; to those who have not, I offer one word of advice—don't.

My introduction to a state prison did not occur in quite the conventional manner. In other words, I was not led through the heavily barred doors handcuffed to a burly officer, finger-printed, given a bath, and a new gray suit four sizes too large; not at all.

I was introduced to the warden in his private office, where I asked for the position of operating engineer, then open. Evidently there had not been many applicants for the place. He sized me up carefully, and asked the usual questions. From his serious demeanor, one would gain the impression that I was a "long timer" hitting the warden for a parole. Later I found that this was his usual disposition.

He launched into a lengthy recital of the numerous rules and regulations governing the inmates, as well as those pertaining to the officers and engineers. He was a stickler for discipline, and I later snagged myself on numerous occasions because of his determination to put discipline above even plant operation.

At that particular prison, they supplied light and power on a 24-hr. basis. The inmates and the two operating engineers worked on 12-hr. shifts. The chief engineer put in about 9 hr.

I was lucky to get the day shift, and reported at 6:00 a.m. The chief showed me about the power plant, and explained in detail all mechanism. I felt quite important, as the engineers were not supposed to do any manual labor; consequently I was clothed in a white collar and tie and a business suit. It was the first time in my life that I had held such exalted position. The trip through the plant disclosed that there were 1500 hp. in water-tube boilers in the boiler house. This was about double the actual need in boilers, but the chief explained that it was often necessary to fall back on these extra boilers. Later I learned that he was perfectly right.

In the boiler room the personnel consisted of eight men, all inmates, as follows: one head fireman and water tender; two hopper fillers, one for each boiler in operation; two pit pullers; one boiler repair man and helper; one porter. From the looks of the place, the porter must have lost his broom, or his mind, or both. I was told the night crew contained four men.

In the engine room were two Corliss engines direct connected to d.c. generators of 300 and 200 kw. output respectively. A smaller outfit consisted of a Skinner engine connected to a 150 kw. generator. There was the usual layout of pumps: Three boiler feeders, duplex type; two hot water service pumps; a centrifugal cold water service pump; a compound duplex fire pump. A basement extended under the entire engine room, and therein were located the vacuum pumps for the heating system, as well as all engine room piping. In the engine room were four men, all inmates. They were listed as engineer, assistant engineer, oiler, porter.

A fully equipped machine shop was operated in conjunction with the power plant, and had its quota of men. There were two machinists, two electricans, three pipe fitters, two handy men. Also charged to the engineering department detail were one institution electrician, one outside electrician and plumber, and two outside pump house men.

With this imposing array of help, I felt that I would not even have to wash my hands at noon time. But I soon discovered that one free employe was worth about five inmates when it comes to getting anything done. Still one cannot altogether blame the inmate for lack of initiative, when it is considered that all he gets for his labor is time, and often a good cussing and a few days in solitary confinement.

I was not long in learning the ins and outs of the plant. I learned largely through actual contact with the work through the never-ending breakdowns, blow-out, blowups, etc.

Rewinding Motor Is My First Job

Things began to happen before I had been on the job 15 min. The outside pump house that supplied the boilers with river water had burned to the ground the night before, due to the inmate forgetting to turn off an electric heater. The chief seemed undismayed at this

bit of information, just as if it had been a neighborhood chicken coop or something. The charred remains of the electric motor were brought in, and I, having had considerable winding experience, proceeded to set in motion the necessary machinery to rewind the machine. Luckily we had a fairly good inmate winder in the shop, and together we managed to get the motor back into shape in less than a week. This was quite a record for that prison. Most of the credit, however, belonged to the inmate, who worked 18 hr. a day on the job. This piece of work gave me a sort of standing about the place, especially with the front office.

On my first day at the prison, I was called to the warden's residence outside the walls. The warden's wife wished to speak to me. On my way out, I wondered what instrument she played in the general scheme of things. The outside plumber must have sensed my thoughts, for he informed me that the madam always called in every new engineer to see if something could not be done about the heating system in the residence. It was the middle of January and cold. I assured her that I would do everything possible to warm the house, and departed with at least one thing to worry about.

Trouble with the Heating System

As there seemed to be considerable heating trouble in various parts of the institution, I obtained the chief's permission to make a personal investigation of the situation. The entire institution covered about 25 acres of ground and was heated by exhaust steam from the engine room. Some of the radiators were as far away as 1000 ft. from the source of heat. The greatest trouble was found to be caused by clogged steam lines. Pipes leading to radiators, and feeders were found to be choked almost solid. In the majority of instances the expanding element had been removed from the radiator traps, and still no heat. The main cell house was heated by a large fan system using banks of coils. Of the nine risers to these coils, seven were completely filled with an accumulation of black greasy solid matter. The heating system had evidently been allowed to get into bad shape through a span of years, and had reached a point where it failed to render service.

Excess Oil Is Cause of Trouble

I began to investigate into the cause of the excess oil in the pipes. I found two reasons for this: One was that the oil separator on the exhaust main may as well have been in Halifax or Timbuctoo for all the good it was doing. The drain from this separator was habitually clogged tight, and nobody seemed to take the trouble to keep it open. Preceding chief engineers had recommended the purchase of a more efficient separator; but state institutions will be state institutions, and nothing was done. The greatest cause of the excess oil, however, I found was not mechanical deficiencies but human inefficiency. As we stated before, the engine room was operated by inmates. These inmates were held responsible for the operation of engine room machinery. It is the unfailing psychology of these men that a little excess of oil to the engines and pumps is better than just enough. With the oil drops chasing one another up the lubricator glass, there is little danger of dry and ruined cylinders, and less danger to the inmate of being introduced to a solitary cell. I fought this reckless oil waste continually, but with little success.

All vacuum return lines were found to be leaking at joints and with holes rusted through in many places. Consequently the vacuum pump had to do excess duty to maintain sufficient vacuum on the system.

As stated before, I started out to be a white collar engineer. Before long I found that a suit of overalls and a blue shirt gave better service, and didn't show the grease spots quite so clearly.

Machinery and equipment can wear out quicker in the average prison plant than in almost any other class of power service. This is due to several causes, namely, inefficiency and inexperience of the operating crew, which is constantly changing; unwillingness on the part of the average prison authorities to replace prematurely worn-out equipment. At the prison of which I speak, the average life of a water-tube boiler is 7 yr. Pumps do not last even that long. Electric motors share an equal fate.

Piping that should be good for years often has to be taken down and reinstalled due to poor threads or strained connections. I had been informed that the boiler header had been installed by prison labor. I believed it after making a careful inspection of the header. A number of the flanges were leaking steam around the pipe threads. I disconnected several of these joints and made up as much as two turns on some of the flanges; more inefficiency.

After about 6 mo. service at the prison, I was made chief engineer, the chief having resigned because of a better connection elsewhere. On assuming the duties of chief I learned that my troubles were only beginning. The warden gave me an increase in salary, but explained this by saying that he did not intend to employ an operating engineer for me. Economy was his watchword. Consequently I continued with my 12-hr. day and assumed the duties of both operating and chief engineer, in charge of the entire institution; and when I say "in charge," I mean that every time a fuse blew somewhere or a pipe sprang a leak somewhere else, the chief's telephone would ring with the request and often demand that a man be sent at once to repair the damage. The repairmen were practically always busy somewhere about the institution, and one can imagine the glory of my position trying to locate some of these men, keeping the plant operating and the inmates on the job, often doing repair work myself, and between times going to the front office to interview salesmen with something to sell.

A 2-T. absorption ice plant of ancient design and several cold storage rooms were operated in connection with the power plant. There was something perpetually wrong with this outfit. Once it would be loss of the anhydrous ammonia charge due to leaks or bursted pipes; then it would be white ice caused by leaky ice cans; then weak brine because the inmate would allow the cans to overflow while filling. There was an automatic can filler in the plant, but it was too much trouble for the inmates to move this filler from one can to the next. The end of a rubber hose was not quite so heavy.

Among the various shops connected with the institution was a large foundry. The power plant supplied power for a large number of motors there. Among these motors was one connected to a blower used in connection with the foundry cupola. It was absolutely essential that

the power should not fail during the time this blower was in operation, usually from 2 to 3:30 o'clock p.m. The largest engine unit was operated during the afternoon to handle the peak load due to the foundry. One day, shortly after taking up the reins as chief, this engine developed a knock at the crosshead. This began about 3:00 p.m. At first I thought I could hold out until the cupola came off at 3:30, but the knock rapidly developed into a pound of such proportions that my hair fairly stood on end. To save the cupola of molten metal, I had to work rapidly. The second engine was not large enough to handle the load, and the smallest unit could not be operated in parallel with the second unit. This was caused by the former chief cutting down on the speed of the smaller outfit because of a fear of a hot main bearing. Consequently the voltage could not be run up to the required point demanded during the foundry run.

I got the second unit up to speed, and then started at one end of the switchboard and began pulling switches. When I finished, practically everyone about the institution except the foundry force was wondering what became of the lights and power.

With the reduced load, the smaller unit finished out the run. On closing down the large engine, we found that the jam nut holding the bottom crosshead shoe had worked loose, and almost any engineer can visualize what was taking place while that crosshead was traveling back and forth along the guides. Luckily no damage resulted, but it was more luck than anything else.

My career as chief engineer of that particular plant came to a climax after about 6 mo. service in that capacity. The boilers had not been cleaned as often as they should have been, due to the failure of the fire pump, which was the only pump about the plant that could be used for boiler cleaning. (Such practice would never be tolerated in the outside industrial plant.)

At 2:00 o'clock one morning, one of the large boilers in operation had to be taken off. Five of the cast-iron headers in the front end and three in the back end had cracked at the second row of tubes from the top. As in all other instances I was held responsible because of failure to keep the boilers properly cleaned, although the night engineer admitted that the water tender may have dozed on the job.

That was the straw that broke the camel's back, so to speak. When the warden hauled me on the carpet and opened up a broadside for my special benefit, I gently informed him that I was no longer a member of his official family, and that he was at perfect liberty to hire someone who would keep the boilers clean. That night I got my first good sleep in more than a year.

Factors Influencing Selection of Oil Engines

First Cost, Maintenance Cost, Reliability and Future of Fuel Supply Considered with Relation to Steam Equipment. By L. V. Armstrong*

ONE OF the most frequent grounds given against the purchase of an oil engine is its high first cost. The writer grants that this is higher than that of a steam engine or a turbine, but it should be borne in mind that the oil engine represents more than just the engine or turbine of a steam plant. It is also the boiler, condenser, feed pump, feed water heater, etc. A comparison, to be made fairly, should be a complete plant of one type against another, and where a new building to house the equipment is necessary, the cost of such a building and the value of the land occupied should be taken into account.

About 6 mo. ago, the writer made a careful and detailed investigation of the relative costs of complete oil engine and steam plants. Only reputable and thoroughly proven equipment of both kinds was considered. Several quotations were obtained and an average taken, so that in neither case were the prices the highest or the lowest at which the machinery could be purchased.

This investigation showed that for a plant consisting of one unit of 200 kw. capacity, the oil engine equipment was 13 per cent more expensive than the steam equipment. If the 200 kw. capacity was divided into two units, the difference, although still in favor of steam, was reduced to 2⅓ per cent. For a 550-kw. plant of one unit, the oil engine plant was 45 per cent more expensive; but when two units were considered, the difference was only 27 per cent.

From these facts, the general axiom may be derived that the oil engine works out most advantageously in small plants or where the operating conditions require the sub-division of the power into two or more units. At first blush, it might seem that the heavy burden which the oil engine plant of one unit of 550 kw. capacity had to carry in the form of increased first cost, would offset the economy of operation. This was found, however, not to be the case.

Simplicity of Plant Extension

Before leaving the subject of first cost, a few words should be said about the ease with which the oil engine lends itself to extension of the power plant to take care of growth. This feature is particularly attractive to a new concern, which has every reason to believe that its power requirements are going to increase rapidly, but which, at the same time, wishes to start off modestly and does not care to tie up money in power plant equipment to take care of future needs. With the oil engine, it is simply a question of providing a temporary wall at one end of the building which can be moved out a few feet to accommodate a second unit. With the steam plant, the problem does not permit of so easy a solution. An additional unit means also additional boiler and condenser capacity, feed pumps, vacuum pumps, stack, etc. If the size of these items is not figured closely for the first unit, then the first cost of the one unit steam plant will be higher and the advantage still remains with the oil engine.

Treading closely upon the heels of higher first cost for the oil engine come the arguments of greater difficulty in obtaining suitable operating personnel, higher repair cost, unreliability, and uncertainty in fuel oil supply.

With the simplification of the oil engine, the problem of getting competent operators has also been solved.

* Ingersoll-Rand Co.

Any experienced steam engineer of average intelligence can with 10 days' to two weeks' instruction learn to run an oil engine. This statement can be proven by a number of instances in which it has worked out successfully. Where it can be done, it is recommended that the prospective chief engineer be sent to the manufacturer's plant to be present during the erection and test period. This procedure, while desirable, is not absolutely necessary.

Proper Maintenance Is Important

The cost of repair parts can be kept down by following a policy of "prevention" rather than the usual one of "cure." Assuming that the machine is properly designed and installed in accordance with sound engineering principles, practically every fatality can be traced to either one of two causes:

1. Overloading;
2. Failure to keep parts in adjustment or improper adjustment.

Little comment is required for the first condition. Anyone who claims to be an engineer should know that a piece of metal which is repeatedly stressed beyond the point for which it was designed will ultimately break down. Oil engines are maximum-rated. This does not mean that they cannot be made to produce more horsepower than their rating, but that their rated horsepower is the maximum at which they should be operated to insure the minimum repair upkeep cost.

Importance of keeping an engine in adjustment cannot be over emphasized. A loose bearing will not only hammer out the babbit metal, but the shock, as the reciprocating masses are brought to a stop at each end of the stroke, may weaken the framing. A loose or improperly adjusted main bearing may result in a crankshaft failure. The way to guard against such troubles is to enforce a schedule of inspection. The value of such a schedule rests in the fact that undue clearances resulting from wear are taken up as rapidly as they occur and not after they reach a point where they are manifested by a knock or a slap.

Reliability is closely related to these subjects of inspection and adjustment. If an oil engine is not subjected to overloading and is kept in adjustment, it will perform as reliably as a steam plant. No service calls for a greater degree of freedom from breakdown than the propulsion of ships. Not only must cargoes be delivered at their destination in accordance with schedule, in order to retain the shipper's trust and patronage, but engine trouble may, when coincidental with bad weather, result in the loss of ship, cargo, and the lives of the crew. The increasing number of motorships, however, can be only taken to mean that the stringent requirements of marine duty are being met by oil engines.

Oil engines are becoming increasingly popular in the ice manufacturing trade. Here an inopportune shutdown may not only cause the loss of 24 hr. production, but what is even more serious, the loss of the confidence of the clientele without which no business can survive.

Future of the Oil Supply

When all other lines of defense have to be abandoned, the last trench in which the opponents of the oil engine take refuge is that of limited fuel oil supply. There are several well-worn routes by which this retreat is made. One is that increasing efficiency in the extraction of natural gasoline is going to result in all of the production of crude oil being converted into automobile fuel. Statistics refute this claim. The report of the Prime Mover's Committee, N. E. L. A., for 1922, contains the following statement:

	Fuel Oil and Gas Oil Per Cent	Gasoline Per Cent	Kerosene Per Cent	Other Products and Lub. Per Cent	Ref. Losses Per Cent
1916	44.9	19.8	14.2	6.1	15.0
1922	51.2	29.3	10.7	4.6	4.2

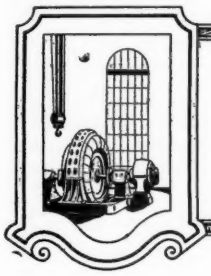
It is true that the percentage of gasoline has been increased, but at the expense of lubricating oil and kerosene, and by reducing the percentage of waste and not by any reduction in the amount of residue fuel oil. As a matter of fact, these authoritative figures show that the percentage of fuel oil produced has been augmented.

Another claim is that we are rapidly exhausting our supply of liquid fuel. That we are squandering our resources like the proverbial rich man's son cannot be denied, but there is no definite knowledge as to when our heritage will be spent and when we will have to seek a substitute. Some experts place the period at 20 yr.; others, at 50 to 60 yr. All admit that while the matter merits consideration, the emergency is well off in the future. Some foresighted engineers are already giving their attention to the extraction of fuel oil from the western shale rock deposits. In the British Isles, this process has been so successful that shale rock oil is now established on a commercial basis. In the United States, the progress has not been so rapid largely because the supply of free-flowing fuel oil has not necessitated it. At an experimental plant of small capacity operated by the Colorado School of Mines, fuel oil was produced at a price of approximately $3 a barrel. Wholesale methods and the improvements growing out of experience will have no difficulty in cutting this cost.

Our deposits of shale rock are estimated to represent a supply of fuel oil several times that of free-flowing oil. A conservative estimate would, therefore, place our total supply of oil from wells and shales as sufficient for close to 100 yr.

United States Civil Service Commission announces an examination for Associate Mechanical Engineer (Power Plant), receipt of applications will close Nov. 20, to fill a vacancy at the Engineering Experiment Station, U. S. Naval Academy, Annapolis, Md., at an entrance salary of $9.12 a day, and vacancies in positions requiring similar qualifications. The duties are to act as technical adviser to the Officer-in-Charge and to take actual control of testing and designing work of power plant equipment.

Competitors will not be required to report for examination at any place, but will be rated on their education, experience, and fitness, on a scale of 100, such ratings being based upon competitors' sworn statements in their applications and upon corroborative evidence. Full information and application blanks may be obtained from the United State Civil Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post office or customhouse in any city.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Protection of Electrical Equipment---I

PROTECTION OF GENERATORS, GUARDING AGAINST OVERLOOADS, MECHANICAL TROUBLES, FAILURE OF LUBRICATING SYSTEM. BY VICTOR H. TODD

MODERN SYSTEMS for the transformation and transfer of electrical energy may be divided into four sections which although closely related and operating as a unit, yet each has its individual characteristics and definite rules regarding protection. These parts are: (1) the generator or alternator, which converts the mechanical energy of the steam or water driven prime mover into electrical energy; (2) the transformer, which

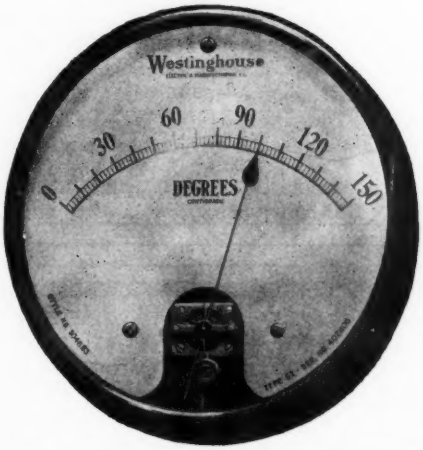


FIG. 1. TYPICAL TEMPERATURE INDICATOR

gives this energy sufficient electrical pressure or voltage for economical transmission, and again lowers the pressure to safe working values where it is desired to use it; (3) the transmission line, which serves to convey this electrical energy to the desired point; and (4) the motor or other load device, which reconverts the electrical energy into mechanical, thermal or chemical energy as desired.

PROTECTION OF THE GENERATOR

There are several general ills from which a generator may suffer, chief of which is excessive temperature which in turn may be caused by excessive load (i. e., too much current) drawn from the generator, or short circuits in the winding, due to defective charred or punctured insulation.

Since temperature is the greatest limiting feature of the alternator, it is desirable to know the temperature at all times and use it either to adjust the load manually or perhaps cut out the machine automatically. The desired place to measure the temperature is on the armature or generating coils. In the generator with revolving field, we frequently find "exploring" coils embedded right in the slots where the active winding is located, consequently this "exploring" coil attains the same temperature as the active winding of the generator.

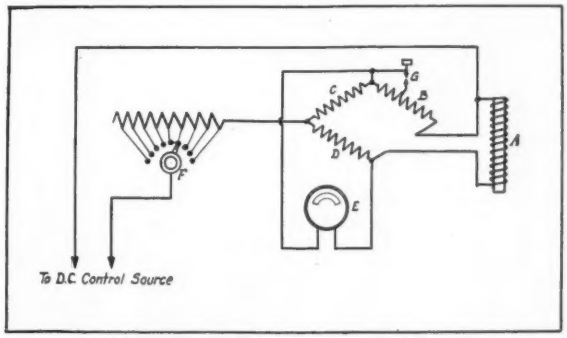


FIG. 2. CONNECTIONS OF THE TEMPERATURE INDICATOR SHOWN IN FIG. 1

An exploring coil is usually about 10 to 30 ohms of copper wire wound on a mica card, thoroughly insulated and provided with heavy wires to connect it to the indicating instrument. The resistance of copper wire varies with the temperature; and then using an instrument to measure this resistance, its indication may be marked in "degrees" or other units of temperature. Figure 1 shows a typical temperature indicator and Fig. 2 shows the schematic diagram of connections, where A is the copper exploring coil embedded in the machine and forming one arm of a Wheatstone's Bridge of which B, C, and D, are the other arms, wound with negligible temperature co-efficient resistance wire equal in resistance to the exploring coil at its temperature of maximum accuracy. A sensitive D'Arsonval type instrument at E and a resistor at F are necessary for correct operation. When the temperature is low, the resistance of A is low and this causes a current to flow in E, giving a deflection toward the low temperature end of the scale. Now, as the temperature increases, the resistance also increases until a point is reached where the bridge balances and no current flows in the indicator. Further heat causes the indicator to deflect to the high side. There may be an error due to variation in control voltage which is proportional to the product of the deflection and the variation, but this may be compensated for by providing resistor F with a switch and taps so that the switch may be set according to the voltage.

It will be also noticed that the exploring coil is provided with three leads instead of two, the object of which is to place one lead in opposite arms A and B, thus preventing any unbalancing due to temperature co-efficient or resistance of the leads. An additional refinement is the test button G, which when pressed, short-circuits a portion of bridge arm B, thus producing a temporary change in the deflection of the indicator and assuring that the outfit is functioning correctly. There may be several of these exploring coils embedded in the machine at various locations, and they may be read consecutively by means of a multi-contact switch.

Another form of temperature measurement employs thermocouples embedded at different points in the generator. A thermocouple may consist of two small wires

FIG. 3. TYPICAL TMEPERATURE POTENTIOMETER

of different material such as copper and a copper-nickel alloy, welded together at one end, while the free ends connect to a measuring instrument or potentiometer.

These two dissimilar metals generate a small voltage which is proportional to the temperature so a measurement of this voltage forms the basis for a determination of the temperature. The potentiometer of which Fig. 3 is typical, is the most accurate instrument to use and indicates temperature within about 1 deg. C. There may be several thermocouples in the same machine, and by means of a multi-contact switch, the operator may read each one, perhaps once an hour and so judge if the machine is operating at the proper temperature.

Figure 4 shows the diagrammatic scheme of the potentiometer with several thermocouples. Note that the alloy wire must be carried clear to the instrument itself and the cold couple formed in the instrument, thus allowing compensation for ambient temperature.

On machines where the armature is rotating such as d.c. generators, the difficulties attendant with placing an exploring coil or thermocouple on the hottest part render it quite impractical to do so; so the next best place is selected and exploring coils are embedded (sometimes wound) directly in the field coils of the generator. Care must be exercised in such cases to remember that there is considerable time lag between the heat in the armature and its transmission to the field.

Overload Protection

Temperature indicators protect against long time excesses, but do not protect against heavy overloads due

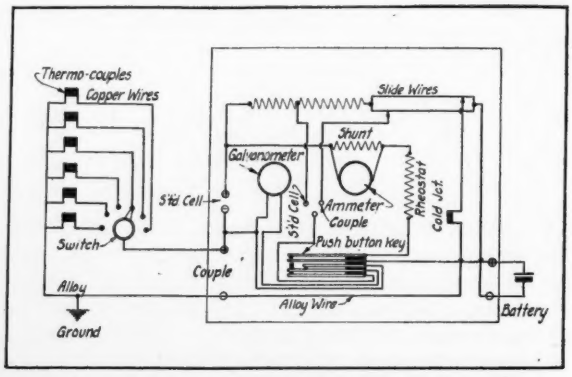


FIG. 4. DIAGRAM OF POTENTIOMETER WITH SEVERAL THERMOCOUPLES

to internal or external short circuits, as these cause an extremely rapid increase in temperature which may burn out one portion of the machine before the excess temperature can communicate to the exploring coil or thermocouple. To protect against internal "shorts" in large generators which are invariably of the polyphase

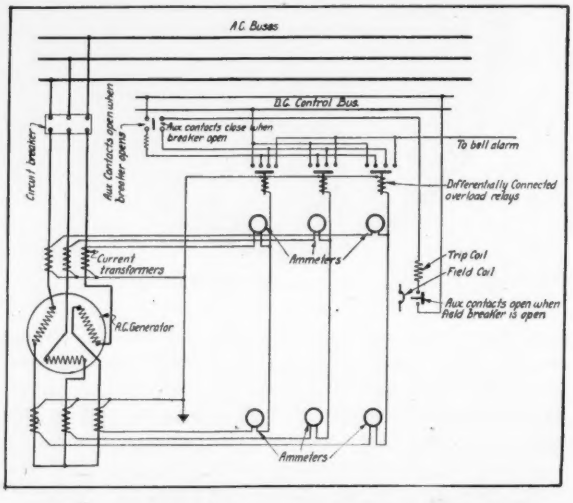


FIG. 5. DIFFERENTIAL PROTECTION OF GENERATOR

type, differential relays are employed, which not only cause isolation of the machine, but also cause the field to open, as it will be realized that an armature with a "short" running in an excited field will cause much damage whether it be connected to the line or not. Ordinary overload instantaneous time relays are used for this with the connection shown in Fig. 5. This scheme requires the opening of the neutral in existing Y connected generators, although many new generators are now built with this protection incorporated in them. As will be noted from the diagram, there is a current transformer primary in the start of a phase winding and

another in the finish, and the secondaries are connected in series so that as long as the same current flows in both start and finish, then the secondary currents will merely circulate and not pass through the relay. But should an internal short circuit occur, this may be fed from both ends, thereby causing a reversal in one transformer whose secondary now bucks its mate, thus sending current through the relay which in turn trips both line and field breaker.

The line breaker may be provided with an auxiliary contact so that the field breaker will not open until the line breaker is open. With this arrangement, there is less liability to damage to the field due to high voltage induced unit if it were opened while heavy currents were flowing in the armature. It also reduces the

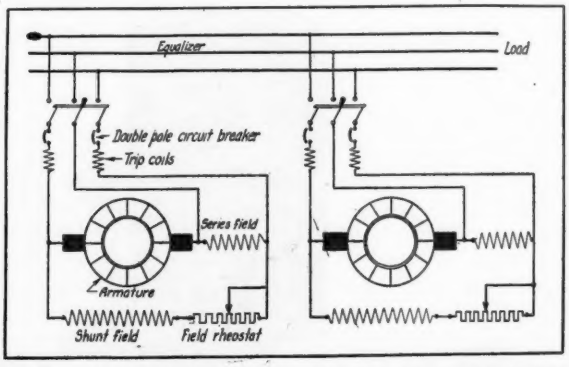


FIG. 6. CORRECTLY PROTECTED PAIR OF D.C. GENERATORS

possibility of the alternator falling out of step with the rest of the system and thereby increasing the disturbance.

Differential protection does not protect from external "shorts" or heavy overloads and consequently we find overload protection between the generator and line or transformer. In small direct current installations, a circuit breaker will give sufficient protection, while its location and correct application are governed by the Underwriters' Rules.

These rules provide primarily that a breaker (or fuse) shall entirely interrupt all current in the armature. Usually a single-pole breaker placed in the armature lead opposite to the one connected to the equalizer bus will do this but for complete protection against external "shorts," and "shorts" caused by a ground in the armature, double-pole breakers should be provided. Figure 6 shows the diagram of a correctly protected pair of direct current generators.

In larger installations, it is often permissible to connect the alternator direct to the step up transformer without intervening protective devices, thus considering the two as a unit. The overload protection may then be on the load side of transformers. In this case, instantaneous protection from external "shorts" is neither necessary nor desirable for two reasons: first, the short circuit current at the first instant may be 20 times the full load current, but within a second or two, this heavy current rapidly decreases due to armature reaction on the field until the sustained short circuit current is only a few times the full load current, and the circuit breaker should not be required to open the circuit until this sustained value is reached; second, many transient "shorts" clear themselves in a few seconds and if the breaker is not opened in the meantime, then the service may continue uninterrupted. Consequently, the breakers are usually controlled by time element relays. Figure 7 shows a typical panel with overload relays on it.

Protection from reverse power (i. e., generator being run as motor with power drawn from bus) was once considered desirable; but this is seldom provided at present, as such reversal cannot damage the generator

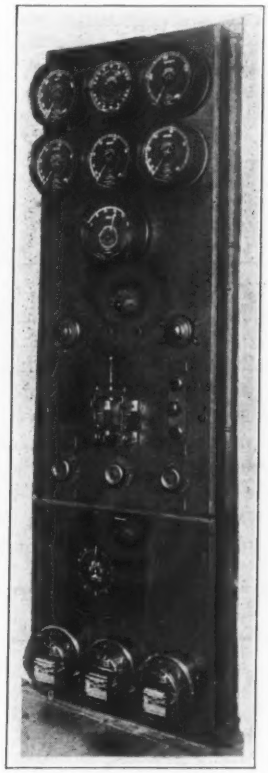


FIG. 7. TYPICAL PANEL OF PROTECTIVE RELAYS

unless excessive, and excess current is taken care of by the overload relays.

Generators with Exciters

Large modern alternators usually have their fields supplied by a small separate d.c. generator which may be tied directly to the generator field without protection, the two being considered as a unit. The a.c. voltage is then controlled by varying the exciter voltage. This is splendidly accomplished by automatic regulators until a heavy "short" so lowers the a.c. voltage that the regulator boosts the exciter voltage to its high limit in an effort to maintain the a.c. voltage. Then should the "short" suddenly clear, the a.c. voltage will rise to such a high value before the regulator can bring it back, that much damage may be caused. Alternating current over-voltage relays may prevent this, but a better plan is to employ an undervoltage relay in combination with a direct current control element connected in the main-contact circuit of the alternating current voltage regulator, as shown in Fig. 8. The contacts of the direct current element and the relay are connected in parallel, the pair being in series with the main contacts of the regulator. The direct current element is

energized from the exciter bus and the relay from the transformer supplying the alternating current regulator.

On a system equipped with this protective device, a short circuit immediately causes the main contacts of the regulator to close and the alternating current undervoltage relay contacts to open, on account of the drop in alternating current voltage. As soon as the exciter voltage builds up to the point for which the direct current

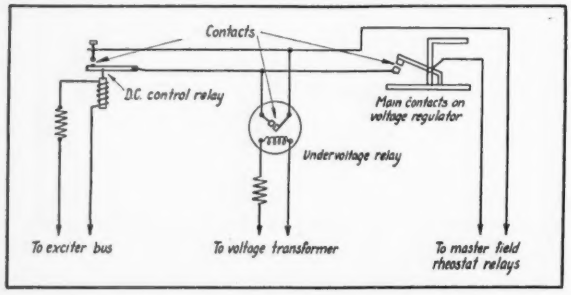


FIG. 8. PROTECTION FROM EXCESS VOLTAGE WHEN "SHORT" IS SUDDENLY CLEARED

element is adjusted, the contacts of this element begin to operate and to regulate the exciter voltage in the regular manner so that the exciter voltage can never rise above the predetermined point, as long as the alternating current undervoltage relay contacts are open. When the "short" is cleared, there is now no excessive exciter voltage to produce a dangerous alternating current voltage. As soon as the alternating cur-

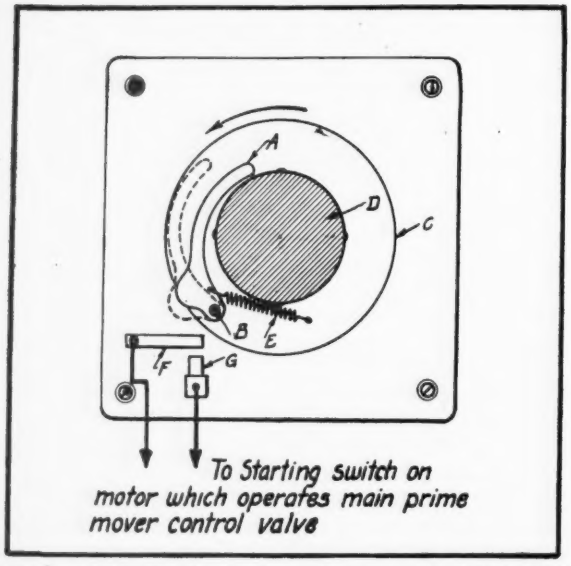


FIG. 9. CENTRIFUGAL DEVICE FOR THE PROTECTION FROM OVERSPEEDING

rent voltage rises enough to close the undervoltage relay contacts, then the control is taken away from the direct current regulator and returned to the regular alternating current voltage regulator, which quickly adjusts the voltage to the exact amount.

Another case of excessive voltage occurs upon the sudden loss of load, when the voltage rises before the regulator can take care of it. To protect against this, an overvoltage relay is used which normally short-circuits an auxiliary field rheostat. Now, should the voltage suddenly rise, the overvoltage relay opens its contacts and cuts this extra rheostat into the circuit, thus dropping the voltage to a point where the regulator can take care of it. Upon generator and exciter speed again becoming normal, this auxiliary rheostat is again short-circuited and the regulator functions in the usual manner.

Mechanical Troubles

Overspeeding of turbines and alternators is often of serious consequence, either due to governor failure or inability to take care of a loss of load quickly enough. The protection in this case may be excess frequency or speed relays, which are, however, a little too sluggish

FIG. 10. G. E. BEARING PROTECTING TEMPERATURE OUTFIT

for perfect protection, and centrifugal devices which attach directly to the shaft and act instantly when the speed suddenly increases above a certain figure. A diagrammatic scheme of one form is shown in Fig. 9. This shows a centrifugal trigger A, pivoted at B, on a collar C, which is fastened to and revolves with the main shaft D. Normally this trigger hugs the shaft due to tension of spring E, and just passes the switch blade F; but should the speed increase rapidly, the trigger is thrown out until it assumes the dotted position, when it now strikes lever F as it revolves, thus closing contacts F and G, which immediately start the motor on the main control valve, thus shutting off steam or water to the unit.

Centrifugal devices on steam engines and turbines may be safely set to trip at about 30 per cent overspeed; but with water turbines, the generator must be able to stand from 90 to 100 overspeed, because, due to the inertia of the water, a water turbine cannot be shut off as quickly as a steam turbine.

Failure of Lubrication

Many machines have been ruined by a failure of their lubricating systems and many devices have been proposed and used with more or less success to prevent this. In the attended station, perhaps the best protection is a careful engineer who will see that bearings are properly lubricated and not running hot. Great impetus has been given to automatic protection by the

advent of the automatic substation where it is absolutely necessary to provide means of stopping a unit should a bearing run excessively hot or the lubrication system fail.

Two methods have proven highly successful, both using pressure gages as relays. The first employs two contacts on a pressure gage which close an electric circuit when the oil pressure drops to a certain pre-determined value. The second, of which a view is shown in Fig. 10, employs a siphon which consists of a pressure gage mechanism directly connected to a small bulb by means of a small metal tube. This bulb is carefully embedded in the bearing to be protected and is filled with a volatile liquid which vaporizes when the temperature approaches the danger point for the bearing and this creates a pressure in the siphon system which communicates with the metal bellows in the relay, thereby opening or closing the contacts which closes down the machine in the automatic station or rings a bell in the attended station. These contacts are usually arranged so that they must be reset by hand, thus assuring that someone visits and inspects the bearings before the machine is started again.

Thermostats are sometimes used on large bearings to close a bell circuit when overheating occurs, while in others exploring coils or thermocouples have been built in the bearings and the temperatures read on the same instruments as previously described. Such devices while not yet the common practice are coming rapidly into favor, due to their great reliability, as the detection of a single overheated bearing may save the cost of the whole protective relay outfit.

Power Factor Problems in Industrial Plants

INCREASING USE OF INDIVIDUAL DRIVE BRINGS ABOUT THE NEED FOR CLOSER ATTENTION TO THE POWER FACTOR PROBLEM.

BY C. W. DRAKE AND H. E. DRALLE*

ALTHOUGH SOME manufacturing establishments have considerable lighting load and others convert some of the alternating into direct current power, the bulk of load in industrial plants consists of induction motors. When induction motor drives first came into general use about in 1900, most of the motors were of comparatively large size and either replaced engines or were used for group drives. On such drives the friction load constituted a considerable part of the total load, or in other words a high load factor was usually obtained which with a large motor resulted in a good power factor. The increasing use of individual motor drive with its recognized advantage has steadily decreased the average size of the motor installed, but has increased the total connected or rated horsepower from 1½ to 3 times that required by group drive. This factor will depend upon the industry and the extent to which individual drive is used. Assuming that the installed motor horsepower in a plant is two times that required for one main drive, it is readily seen that the energy consumed per day (kw.-hr.) with individual drive will be much less than with group drive, due to the elimination of much shafting and also to the shutting down of various machines when not in use. On the other hand, the use of a larger number or a greater horsepower of smaller motors requires a greater magnetizing or reactive kv.a. than a few large motors. So it is that the progress that has been made in obtaining greater efficiency, greater simplicity, reliability and production, has all tended to give a lower plant power factor. This does not indicate that the previous steps were improperly taken but simply that the time has come when this question of maintaining good power factor should be considered in conjunction with every plant extension or revision. To do this intelligently requires, first an intimate knowledge of the various factors and machines which cause low power factor, and secondly a knowledge of the apparatus and methods available for improving power factor.

Acknowledging the induction motor as the principal cause of low power factor in industrial plants, a careful study of its characteristics and use reveals much of value and interest. Every manufacturing plant using induction motors will have a certain power factor depending principally upon:

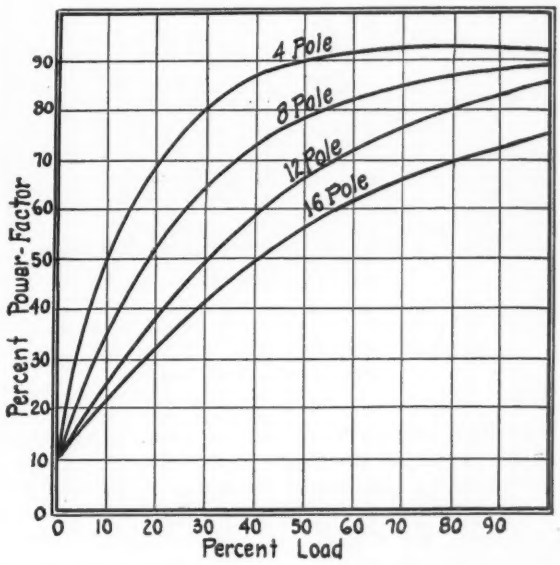


FIG. 1. POWER FACTOR CURVES OF INDUCTION MOTORS AT VARIOUS SPEEDS AND LOADS

(1) The frequency of the power supply,
(2) The type, size and speed of motors used,
(3) The per cent of rated load carried by each motor.

It is found, for instance, that the power factor of plants using low frequency, such as 25 cycles, is higher than that of similar plants using higher frequency. This is simply due to the fact that the power factor of an induction motor decreases as the number of poles increase, so that where a four-pole, 25-cycle motor would be used a 10-pole, 60-cycle motor would be required to give a similar speed. Other conditions being similar, the power factor of a 25-cycle installation may be from 5 to 10 per cent higher than that of a 60-cycle installation and in many industries using 25-cycle power the normal

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power factor is sufficiently high so that no power factor correction is required.

For a given horsepower and frequency the slower the motor speed the larger the frame required, consequently a greater amount of magnetic material and magnetizing kv.a. will be required. Strictly speaking it is the air gap rather than the iron that requires most of the magnetizing kv.a., but since the area of the air gap is determined by the frame used, we may think of, or visualize the magnetizing kv.a. as approximately proportional to the physical size of the motor. A large magnetizing or reactive kv.a. for a small horsepower output, that is a slow speed motor means a poor power factor and is simply another way of stating that the power

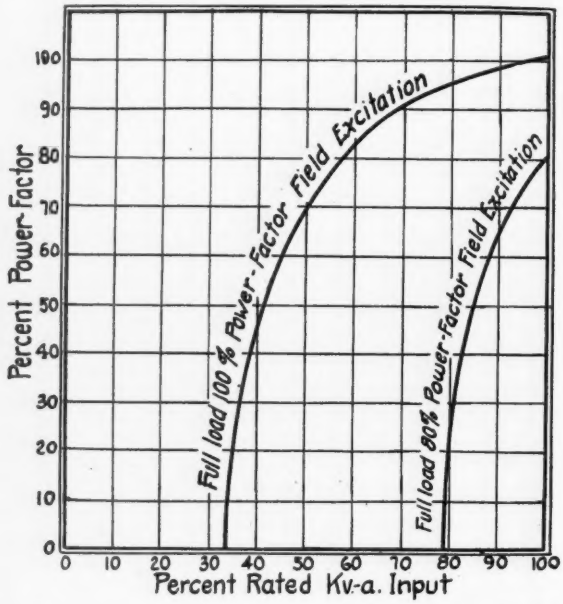

Percent Power-Factor
Percent Rated Kv-a. Input
Full load 100 % Power-Factor Field Excitation
Full load 80% Power-Factor Field Excitation

FIG. 2. CHARACTERISTIC CURVES OF STANDARD SYNCHRONOUS MOTORS FOR 80 AND 100 PER CENT POWER FACTOR OPERATION

factor decreases as the number of poles increases. So roughly speaking, the magnetizing kv.a. in a plant is determined by the amount of magnetic material connected to the line at any time. The higher the speed of the motors, the greater the total horsepower output, consequently the greater the energy component and the higher the power factor; therefore, it is of prime importance, in making the motor application, to use as high a speed motor as is consistent with the method of drive. On the other hand, the question of power factor should always be secondary to that of making a satisfactory mechanical or electrical application. The trouble that may be caused by using too high a gear speed or a pulley too small for the horsepower transmitted, will much more than offset a slight gain in power factor.

In a similar manner, it may be seen that as the load on a motor decreases the power factor also decreases. The difference in power factor between two different loads that is the shape of the power factor curve, will depend upon the type, size and speed of motor, but in general it may be said that high speed motors not only have the highest power factor, but also the flattest curves, while the power factor curves of slow speed motors are quite steep. Figure 1 shows characteristic curves of induction motors for various speeds and indicates the poor power factor that will be obtained on slow speed motors, especially when under-loaded.

Over-Motoring

Over-motoring, or the installation of motors having capacity in excess of the requirements, results in oper-

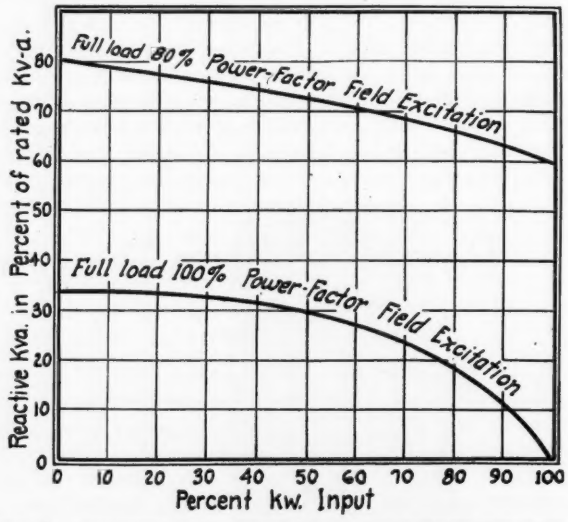

Reactive Kva. in Percent of rated Kv-a.
Percent kw. Input
Full load 80% Power-Factor Field Excitation
Full load 100% Power-Factor Field Excitation

FIG. 3. REACTIVE KV.A. OBTAINABLE AT VARIOUS MECHANICAL LOADS (DERIVED FROM FIG. 2)

ating the motors at fractional loads and low power factor, and may be caused by any one or a combination of the following items:

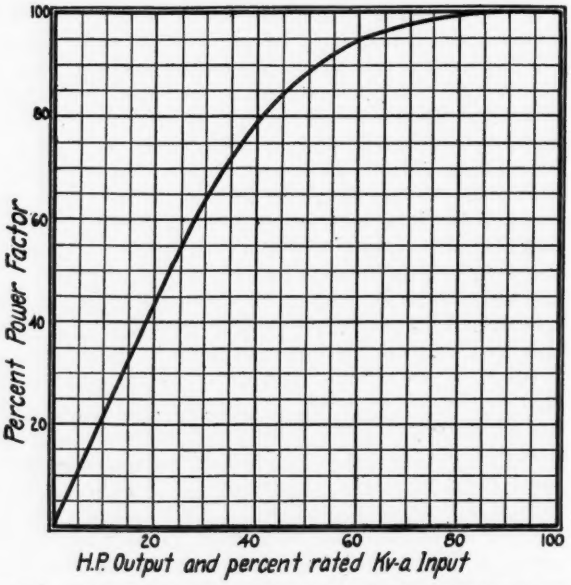


FIG. 4. CURVE SHOWING EXCESS HORSEPOWER RATING OF SYNCHRONOUS MOTOR CANNOT BE USED FOR APPRECIABLY RAISING POWER FACTOR

(1) The desire of the user to have ample capacity for any emergency or future load conditions.

(2) The desire of the user to operate a motor at a very low temperature.

(3) A change in manufacturing or production conditions since the installation was originally made.

(4) Lack of information by either the user or the manufacturer's representative regarding the exact power requirements, coupled with the desire to avoid a motor too small or in other words "playing safe."

Motor salesmen may be responsible for over-motoring in some cases, but investigation in many plants indicates that the user often desires motors larger than apparently necessary, and in many cases he is justified in doing so. Take, for instance, a rubber mill line drive. Tests on different compounds have shown that one may require twice as much power as the other, yet the compound requiring the maximum power may be used only at rare intervals. Again, who can predict what new compounds may be discovered and what their power requirement will be? Consequently, unless there are enough duplicate units so that motors of different sizes may be used, it is common to install a motor that will carry any stock the mills will handle. This necessity, in many cases of motoring for future or maximum requirements, means that the motors operate at a fractional load and with poor power factor most of the time.

We have seen that low power factor in a plant may be caused either by the use of slow speed induction motors improperly loaded, or by any induction motor partially loaded or any combination of these. The application engineer can, however, utilize this information only to a limited degree for it is his duty to estimate the power requirements of the machine to be driven as accurately as possible, to study its operation in order to determine the type of motor to use and the method of control to give the maximum production. The motor speed will be determined by the most suitable mechanical drive, and the power factor obtained is simply the result of the above chain of engineering reasoning; however, after the problem has been solved once it is entirely in order to go over it again and see what changes might be made that would improve the power factor, and then compare the advantages and disadvantages of the two layouts from the engineering, production, investment and operating standpoints. Any comparison should include the entire drive installed, since in some cases clutches, extra bearings, foundations or special controllers might be required, which would not be necessary with the other motor drive. In general, it is safe to say that the motor and controller which best meets the manufacturing requirements, will be found best although application engineering is not an exact science and there are often several solutions to each problem.

Means of Improving the Power Factor

Correction or improvement of the power factor in an industrial plant means that for the same energy load the reactive kv.a. must be reduced. This can be accomplished in two ways as follows:

(1) By rearrangement of motors so that each is operating more nearly at its rated capacity.

(2) By the installation of apparatus which will supply the necessary reactive kv.a.

After a plant has been operating long enough to get into steady production and the machinery is well broken in, the management should be interested in conducting quite complete tests on the motor equipment to determine not only the average load but the nature of the load on each particular machine. A study of such graphic meter charts by a production engineer gives a good insight into manufacturing conditions, while the same chart tells the electrical engineer what the motor has to do. Often after an investigation of this kind it is possible to use smaller motors and thus raise the power factor at the source, that is by reducing the reactive kv.a. required. This may or may not give a suitable power factor but the following is an example of a plant in which both methods of correction were used. A metal working plant had a large number of presses and shears, most of them individually driven. The original power factor varied from 45 to 55 per cent, but this was raised by a rearrangement of motors to about 60 or 65 per cent. A high power factor could not be expected since the load factor on most of the motors was exceedingly low, some of the presses making a power stroke only once in several minutes. There was a demand for a small motor generator set to supply direct current and a large synchronous motor was chosen to drive this. This synchronous motor operating at about 50 per cent leading power factor gave the resultant or total plant power factor desired.

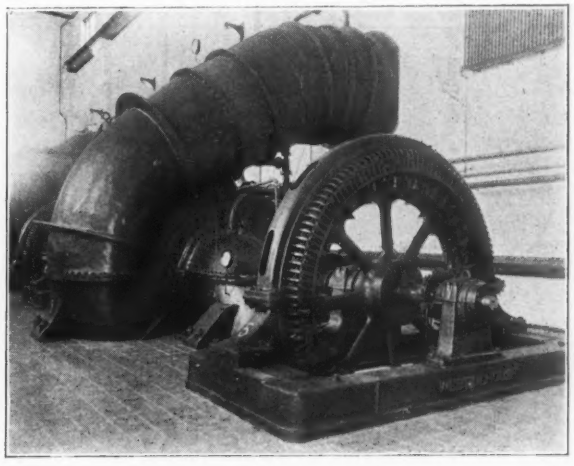


FIG. 5. TYPICAL INSTALLATION OF SYNCHRONOUS MOTOR (1100 HP.) DRIVING LARGE SEWAGE PUMP

Use of a synchronous motor, either operating idle as a synchronous condenser, or carrying some mechanical load, but with an over-excited field, is probably the oldest and best known method of supplying the reactive kv.a required for power factor correction. The design and construction of synchronous motors are such that it is possible to build them for extremely slow speed with good performance and yet at a much lower cost than a corresponding induction motor. These characteristics have made possible the direct connected air and refrigerating compressors which are now extensively used, and the increasing number of these is doing much to improve the station power factor. Most of these compressor motors are designed for 100 per cent power factor operation, but where the conditions warrant, motors for 80 per cent leading power factor can be supplied.

It is not necessary, however, to hunt for a direct current generator or a compressor in order to find a place to use a synchronous motor. Fans and pumps both of the centrifugal and plunger type are now driven with synchronous motors, while by proper attention to the starting and pull-in characteristics, synchronous motors

may be used for nearly any constant speed drive. It is sometimes a question whether one is justified in trying to adapt a synchronous motor to some load for which it is not well fitted or whether it would not be better to use the proper correction some other way. If some mechanical load can be obtained, however, the investment and operating expenses of the motor are divided between the two functions performed, and the power factor correction is obtained at a minimum cost. The curves in Fig. 2 are characteristic of standard synchronous motors, one being designed for 80 per cent leading power factor and the other for 100 per cent power factor operation. They indicate the per cent of rating that will be obtained when operating at other than normal power factor and at zero per cent power factor give the capacity as a synchronous condenser. With the 100 per cent power factor motor it is noticeable that a large reduction in load is necessary before a high leading power factor is obtained.

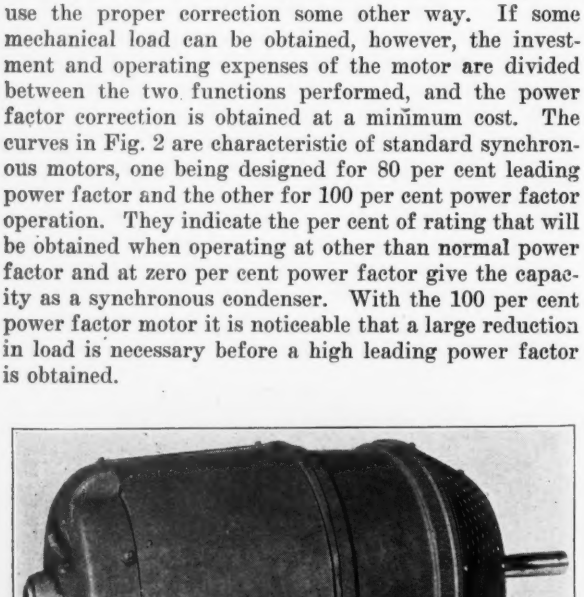


FIG. 6. INDUSTRIAL PLANTS USING LARGE INDUCTION MOTOR DRIVES SOMETIMES FIND IT ADVISABLE TO USE PHASE ADVANCERS FOR CONNECTING POWER FACTOR OF INDIVIDUAL MOTORS

Figure 3 is derived from Fig. 2, but shows more clearly the reactive kv.a. obtainable at various mechanical loads. Motors designed for 100 per cent power factor are ordinarily operated nearly at their rated load and whatever power factor correction is obtained is due principally to the addition of load at or near 100 per cent power factor. If such a motor is operated at about two-thirds of its rating, a reactive component equal to about 75 per cent of the maximum is obtained and this makes a very economical method of operation. With the motor designed for 80 per cent power factor at full load, the reactive component varies little with the load and, except under unusual conditions, there should be no excuse for running at fractional loads. For instance a reduction from 100 per cent to 75 per cent in the load increases the reactive kv.a. from 60 to only 68 per cent.

Synchronous Condensers

Where no mechanical load is available, a synchronous condenser is often supplied and may simplify the power factor problem by having all of the apparatus concentrated at one point. On the other hand, it is necessary to check carefully to see whether the savings in the cost of energy will pay for the fixed and operating charges of the condensers, which charges in the case of motors are largely charged off to manufacturing expense.

There is another method of improving the power factor about which comparatively little is generally known. It is applicable only where large wound rotor motors are used and where they operate at constant speed and consequently is not applicable to hoists, cranes, etc. Motors of these characteristics are often used extensively in rubber mills, flour mills and similar plants for driving mill shafting, ranging from 150 to 500 hp. at speeds from 435 to 580 r.p.m. In many cases, the major part of the load consists of these large motors and since these generally operate at low speed and sometimes at low load factor, poor power factor is common. The power factor of such installations could be improved by means of a phase advancer.

This is a small rotating armature machine designed to supply the magnetizing current for the induction motor. The brushes on the commutator are connected to the slip rings of the induction motor after it is running at full speed and when the advancer is driven at the proper speed, either by a separate motor or a belt from the larger motor, a power factor of approximately 100 per cent may be obtained over the usual load range. Little change in the control equipment is necessary and the connections for the advancer may be so arranged in the main controller that no additional operations are required. The use of a phase advancer makes it possible to utilize the starting characteristics of the wound rotor induction motor and at the same time to obtain the operating characteristics of a synchronous motor. The field of application for phase advancers is undoubtedly quite limited, especially due to the fact that a high leading power factor is not feasible, consequently the power factor of the plant is affected only by the addition of a 100 per cent power factor load.

Static Condensers

Although the principles of static condensers were known long before the problem of power factor correction was talked of, it was not until recently that commercial sizes were available at a price which made them attractive except for laboratory purposes. Since static condensers supply reactive kv.a. only and in definite amounts, there are no particularly complicated problems to be met from an engineering application standpoint. It is necessary simply to estimate the kv.a. required for any plant and then install a condenser of suitable capacity. Static condensers do not lend themselves readily to the maintenance of a constant power factor with a varying load, while this is readily accomplished with a synchronous machine. In some plants, as for instance, those operating 24 hr. a day, this control of power factor is often an important feature. In those plants working at a fairly uniform load for only one shift per day, a fixed condenser capacity may be satisfactory. The static condenser will undoubtedly find wide application, especially in small plants having no opportunity to use synchronous motors or phase advancers, while its simplicity appeals to this class of customers. On the other hand, in the large manufacturing plants it is usually not difficult to find some load for a synchronous motor, and when this can be done, power factor correction is obtained at a much lower cost.

Problems in Power House Ventilation

A Study of the Principles Underlying the Control and Movement of Air in Power Plants Based Partly on the Prime Movers' Report of the N. E. L. A.

IN CONSIDERING the proper supply of air for central stations, and its preparation, circulation and distribution, the term "ventilation" is hardly adequate. This term generally implies that tempering or conditioning and movement of air which are necessary for the health and comfort of the people occupying any building.

These strictly ventilating problems have been given much study by individuals and organizations over a great number of years, so that the subject is generally well understood and properly handled. However, that part of the problem which covers the supply of air for central station equipment, as well as for the comfort of the personnel has only recently received serious attention from designing and operating engineers.

The seemingly sudden increase in the complexity and number of the problems of ventilation as met in power houses, is undoubtedly due to rapid increase in the size of the stations and the equipment which they contain. A few central stations recently designed and constructed show that considerable attention and study has been given the subject, but the greater number of power plants all over the country evidence the fact that it is not sufficiently understood and considered and the losses and discomforts which are being suffered only emphasize its importance.

If out-of-door temperatures were uniform and moderate, or if equipment could be installed in the open where the breezes and natural movements of air would be unrestricted, there would probably be no ventilation problems. In climates in which the temperature may vary 100 deg. from summer to winter, however, considerable ingenuity is necessary, first in the design of a station, and later in its operation, to get proper air circulation.

Following the suggestions offered by the simplest case imaginable, which has just been cited, the equipment and necessary buildings should, whenever possible, be so arranged as to provide for the natural movement of air due to conditions of temperature, humidity, etc., as this will result in simplicity and economy of operation, and the attention and expense necessary for forced draft ventilation may be eliminated.

Where forced ventilation is necessary, however, the designer will first be impressed by the immensity of the volumes and weights of air which it will be necessary to move, as well as the considerable amount of power required. He may later be surprised at the futility of his efforts, due to eddies and counter-currents which may be set up, or by phenomena which may develop due to conditions of temperature or humidity which had not been anticipated. Further than this, with varying temperatures, considerable attention may be necessary from the operating personnel, and the operation of a perfectly devised system may be made impossible through lack of proper understanding on the part of those charged with its operation.

Some of the problems to be considered in connection with air supply are: the conservation of air which has been heated by use in certain parts of the equipment or by contact with equipment during cold seasons of the year and the release or venting of this air during warm seasons; the utilization of this air in boiler furnaces without undue expense of power or attention; the prevention of fog in turbine rooms and the elimination of the collection of moisture on roofs and walls and particularly on air or water cooled equipment; and last, but by no means least, is the consideration of the comfort of the operating personnel.

Aside from the fact that there is positive economy in supplying comfortable surroundings for the men employed, it is absolutely necessary properly to ventilate those parts of the station in which men must work continuously. Steam and gas must be removed from ash alleys, but the air supplied must be tempered so that reasonable working conditions will result, while the spaces back of boilers and above boilers must be taken care of to avoid the extremely high temperatures which would otherwise result and to remove any smoke or gas arising from stoker hoppers or settings. Unloading sheds must be considered and the warming of these spaces in winter as well as the cooling in summer, and the removal of coal dust, must properly be provided for.

All operating men have seen stations in which certain localities are unbearably hot both in the winter and summer, while others are unbearably cold in winter; where men in the ordinary performance of duty are required to move into a cold room from one which is hot or filled with gas and steam; where men are required to work continuously in an atmosphere of gas or smoke; where under certain weather conditions turbine rooms are filled with heavy fog; where water drips from the ceilings and walls and where the ice forms overhead on monitors and windows, endangering the safety of those working below at times of changes in temperature. They have seen times of changes in temperature. They have seen stations where it was necessary to keep the boiler room closed in order to make conditions livable and in order to prevent the freezing of pipes and equipment in certain exposed parts of the building, which has resulted in a difference of pressure of ¼ in. between outside and inside of building walls, so that cold air would be squirting through every available opening. Under these conditions the operation of the boiler room may be seriously affected.

Boiler Room

As the boiler room requires the greatest amount of air for its operation, it will be considered first. Under the most favorable conditions, approximately 12 lb. of air are required per pound of coal consumed, which means that a plant using an average of 50 T. of coal per hour would require 600 T. of air in the same period, or over 250,000 cu. ft. per min. at average temperatures. This air should be supplied, if possible, from those parts of the station where there may be excess air which has already been heated, or should be taken in in such manner that the radiation from high temperature equipment will be taken advantage of. It is necessary to take it in in such a manner that cold drafts, particularly in that part of the building in which men must work, will be avoided.

In the case of stoker-fired plants at least, this great quantity of air must be led to the space beneath the boiler-room floor, that is, in general, to the bottom of the boiler house. All the natural convection currents in the boiler room are upward, therefore, any attempt to use the air heated by boiler room equipment will be most successful if it permits that air to rise to gathering points at or near the top of the room and then draws it down through spaces in which no upwardly directed convection currents exist. The same principle applies to the conservation of heat in the heated air rising from equipment in the turbine room. If this heated air is to be used for combustion, it is most easily gathered at the top of the turbine room and led down through a space in which no opposing natural currents exist. It should be remembered, however, that all air used for combustion passes out through the stacks and that an equivalent quantity must therefore constantly enter the station.

Under summer conditions, this presents no very serious problem, as it can be admitted at almost any available point. The best results will be obtained when it is so admitted as to sweep away noxious gases, smoke and the like from all places in which such things may collect.

Under cold weather conditions, the problem is more difficult, as this large volume of air must be admitted in such a way as not to make uncomfortably cold any of the working spaces in the plant, and at the same time so as not to strike steam pipes, hot water lines or other similar equipment. This can be done, if proper provision is made in the design of the plant. Some of the available methods of accomplishing this result will be shown in the latter report referred to above.

While ducts may be necessary in certain localities, it is possible that the arrangement of the equipment and the location of stairways and floor and wall openings may be such that natural ducts will be provided for the movement of this air. Fans may, and often will be necessary to direct the flow positively at certain points, but it is generally possible so to arrange things that the air may be otherwise directed, and that the natural flow due to differences of temperature and pressure will be sufficient.

Turbine Room

In the turbine room the ventilation problem is more complex and serious. The room is filled with machinery and piping operating at various temperatures, each piece setting up air currents more or less local which affect the distribution of air throughout the room as well as the equalization of temperature. As each hot steam pipe sets up a rising column of air, just so each cold water pipe produces a current in a downward direction. Steam which escapes from vents, packings, etc., adds to the humidity of the air, producing currents in effect the same as those produced by changes in temperature.

Cold walls and windows produce downward currents along these surfaces and cause condensation of moisture from the warmer, saturated air which comes in contact with them. Ceilings and skylights have the same effect, although it is becoming quite common practice to guard against the collection of moisture on ceilings by the use of insulating materials, or dead air spaces.

In condenser pits and alcoves, the temperatures are often exceedingly high and the air saturated with moisture so that working conditions are extremely unpleasant. In many instances it has been found advisable to provide forced ventilation for such locations in order to improve working conditions.

In some instances a part of the air for the boiler room is taken through the turbine room either intentionally or otherwise. This generally results during the cold weather in incoming blasts of cold air causing a heavy fog either locally or throughout the entire room.

Methods used for cooling the generators must also be given consideration. When an open system of generator cooling is used, the problem of admitting and tempering the necessary air quantities must be solved, but on the other hand, the air discharged by the generators is available for heating the turbine room and basement when necessary, or as combustion air if desired. When used in the latter way, it will generally form about half of the required amount.

When a closed system of generator cooling is employed, the problem of getting a continuous supply of air into the turbine room is eliminated, but correspondingly, the discharged air is not available for such uses as are indicated above.

It is obvious that the natural convection currents in turbine room will be upward over the greater extent of the area of the floor during both summer and winter. During cold weather there will also tend to be downwardly directed currents on all walls which contain large areas of glass or are for other reasons at lower temperatures than those of adjacent spaces. Similarly, cold roofs and skylights will serve as sources of downwardly directed currents. Any successful turbine room ventilating scheme must take these natural convection currents into account.

Switch and Bus Compartment

In the switch and bus compartments, the circulation of air is generally a comparatively simple matter. In the first place, there are few men employed in this part of the plant, and it is necessary only to maintain fairly uniform temperature with a reasonable change of air. A forced ventilation system, however, should be provided for clearing these rooms of gas and smoke which may result from electrical disturbances, in order to hasten and facilitate the work of restoration after a case of trouble. The amount of air ordinarily handled is so small that its disposition is of minor importance. The problem can properly be classed as a heating and ventilating problem.

In small stations, however, where this equipment is located in the turbine room, care must be taken to maintain the temperature of busses and switches above the dew point of the air in the room. With peak load stations where the equipment is shut down for several hours and the temperature of the room and the equipment drops to a comparatively low point, condensation may take place on this equipment when the station is again started up. Under such conditions, the electrical equipment should be enclosed in a heated room or heating equipment should be installed to maintain uniform temperature throughout the turbine room.

With equipment so located there is also the danger of water dripping onto it from ceilings or collecting on walls and windows and running across the floors. There is also the danger of fog, which occurs frequently in plants operated under these conditions.

Which? Coal or Oil

IT MAY BE LESS COSTLY TO BURN OIL NEXT WINTER INSTEAD OF COAL. BY W. F. SCHAPHORST

OIL IN COMPETITION with coal is with us to stay. This applies to both high and low pressure boilers in power plants, industrial plants, and under house-heating boilers. It has in recent years been predicted numerous times by engineers that oil burning would not make any headway because of the increasing scarcity of oil. Today, however, although the demand for gasoline and oil is constantly on the increase oil producers are having little if any difficulty in meeting the demand. In fact, at the present writing producers are complaining because they have too much oil in stock and that there is not sufficient demand for it.

In order to produce ample and inexpensive gasoline, a number of new processes have been perfected to increase the percentage of gasoline from the crude state and decrease the percentage of residue. The result has been more gasoline, true enough, but at the same time,

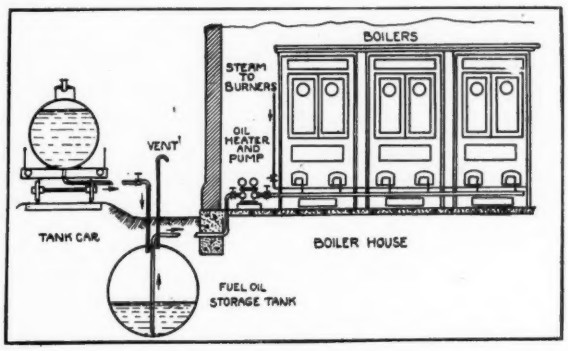


FIG. 1. SKETCH SHOWING SIMPLE METHOD OF OIL STORAGE AND THE GENERAL PIPING ARRANGEMENTS FROM THE TANK CAR TO PUMP AND THEN TO THE BOILERS

despite the decreased percentage of residue, there has resulted an abundance of residue. This residue is the fuel oil that we now find glutting the market, being sold and used in active competition with coal.

All who use coal will surely welcome any substitute that produces as much heat as or more than coal, and at a lower cost. All of us will welcome any substitute that will enable us to avoid the coal scarcity and the strike annoyances that spring up nearly every year.

Naturally one of the first questions that the purchaser always asks is: "Will it pay me in dollars and cents to change over from coal to oil?"

In reply to that question, I will give some actual data comparing the cost of burning fuel oil with the burning of coal. In one of the principal manufacturing cities of New Jersey, at the time of compiling these figures, the price of coal per ton varied from $8.14 to $11.00 per 2000 lb. The price of fuel oil per gal. was 5¾c delivered. The oil had a heat value of 18,846 B.t.u. per lb. The heat value of the coal has figured to be 11,000 B.t.u. per lb.

It is easy to show on the basis of a specific gravity of 0.940, which the oil had, that one gallon of oil produced 148,000 B.t.u., and that one ton gave 11,000 × 2000 = 22,000,000 B.t.u.

In burning coal, there is usually about 2 per cent loss with the ashes which produces no heat. Knowing this it is then a simple matter to show that one ton of coal is equivalent to 145.5 gal. of oil.

Averaging the cost of coal ($8.14 plus $11.00 and dividing it by 2) gives us $9.57 per ton for the coal, while 145.5 gal. of oil at 5¾c makes the cost of oil $8.36. Subtracting $8.36 from $9.57 gives $1.21 as the saving per ton of coal burned. In this plant 300 T. of coal were burned annually, amounting to a computed saving of $363.00 The total cost of the oil burning installation was $1560.00 the interest on which amounts to $93.60.

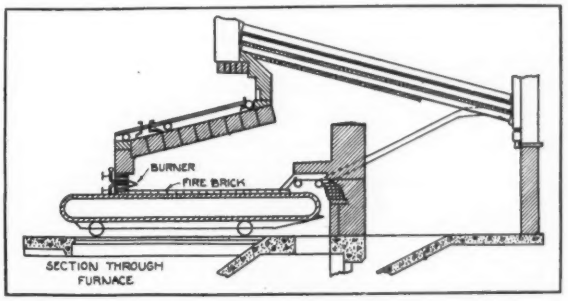


FIG. 2. THIS SHOWS HOW A CHAIN GRATE FURNACE WAS CONVERTED TO OIL BURNING. IT IS SIMPLY A MATTER OF LAYING FIRE BRICK ON THE GRATES AND INSERTING THE BURNERS

Subtracting this from $363.00 gives the net saving per year as $269.40.

This saving in itself is worth while, but in addition there was a much larger saving of $1200 per year due to the elimination of an assistant engineer who did the firing, removed the ashes, etc. Besides, there was a further saving in fuel because of the greater efficiency of the boiler. Oil burning almost invariably gives a higher efficiency because combustion is more complete. There is no smoke and there should be no soot. It is well known that soot, when it adheres to the boiler tubes and on the shell, is a most effective insulator. Soot keeps the heat out.

For instance, the writer knows an installation in New York City where the over-all efficiency with coal burning was 63 per cent. On converting over to oil burning the efficiency became 79.6 per cent. This is due to the better combustion obtained with oil and to the cleaner boiler surfaces.

THERE IS little or no demand for the services of workers without eyes. No more terrible catastrophe can be imagined than the moment following the realization that the bodily functions are perfect, except that light has left the eyes. The safety engineer and those especially interested in preventing industrial accidents feel disheartened many times at the risks men take with the precious sense of sight. Protective devices are not always used. The sum of $13,580,502 was awarded for permanent injuries in Pennsylvania between Jan. 1, 1916, and June 1, 1923. Eyes were credited with $5,617,286; hands, $3,150,187; legs, $1,447,037; arms, $1,127,118; feet, $1,459,786; and miscellaneous, $769,088. The foregoing indicates that 41.4 per cent of the total amount of compensation awarded for permanent injuries was for loss of eyes.—California Safety News.

Accidents, Their Causes and Remedies

NOTES FROM THE REPORT OF THE ACCIDENT CAUSES AND REMEDIES COMMITTEE OF THE NATIONAL SAFETY COUNCIL

MUCH OF OUR most valuable knowledge comes to us as a result of a mistake—that is, through experience. Accidents are mistakes and must therefore be considered as experience. To realize on an accident is like collecting revenue from the refuse.

Now, some companies have accidents, and while they realize their seriousness and deplore them, they keep right on having more. With the thought of getting a closer insight into the root causes of past accidents in the public utility industry, a committee was appointed by the National Safety Council at their convention in Detroit in 1922, for the purpose of making a diligent study of accidents and offering some suggestive remedies for the possible elimination of future ones. Some of the

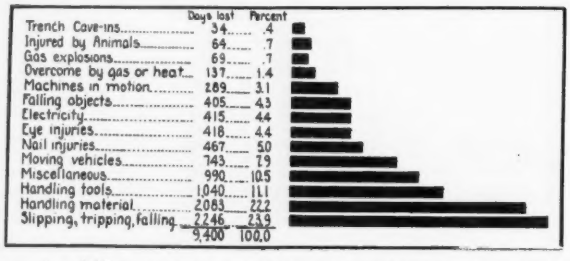


FIG. 1. 9400 REPORTED ACCIDENTS INVOLVING LOST TIME ANALYZED AS TO IMMEDIATE CAUSES

conclusions arrived at by this committee are incorporated in the following abstract of the report which was presented at the recent safety conference in Buffalo.

REVIEW OF ACCIDENT PREVENTION SITUATION

Working conditions in a public utility are far different from those in any other industry. The employes are widely scattered, and their work is much diversified. They are not concentrated as in a mill or factory where training is comparatively easy. Neither do the accidents which occur follow the general characteristics of those which happen in other industrial concerns. An employe in a factory may be working day in and day out at a punch press. A lineman in an electric utility may be connecting lightning arresters this hour, stringing wire the next, climbing poles the next, and so on. The factory employe may get hurt at his job. Possibly the remedy would be a punch press guard. The utility employe may get hurt at his job. Possibly the remedy in this case would be a system of training the employe in his work, the need for an all-seeing foreman to anticipate accidents and to supervise his many hazardous duties, or many other possible cures.

In studying the causes of these accidents, it required only a first glance to classify them according to the original classification, such as Handling Tools, Electricity, Slipping, Tripping and Falling, etc. This classification is possibly the only kind that is suitable for insurance and statistical purposes, but from the standpoint of suggesting means of preventing future accidents, it is of no value. This kind of classification does not point out why an accident happened or who is to blame. It does not say whether the foreman had failed to caution or instruct the injured regarding his work, or whether the injured has violated rules. It does not determine the human equation that possibly may be the cause of the accident and which is so often termed "carelessness." Consequently it was necessary to go far beyond these surface causes and look considerably deeper for the fundamental reasons why these accidents occurred. Many contributing factors began to appear and there was revealed the fact that the root causes, in the majority of cases, were due to the lack of responsibility on the part of either the injured workman or his supervisor.

A report of an accident from one company says an employe received a broken leg and ankle when, in assisting to unload a car of poles, one of the poles rolled off the car and knocked him down, resulting in three months disability. The foreman was on the job, supposedly supervising the work. He was at one end of the car and watched this man walk up to the side of the car to remove the last stake and let the poles roll off. The injured man figured he could get away before they fell. This accident is typical of many others. Its cause lies in the fact that the foreman did not shoulder his responsibilities. Certainly the method pursued was not suitable for the work and the issuing of specific instructions for the performing of certain jobs is most assuredly the duty of a foreman.

In a certain company, a lineman was electrocuted and the safety engineer was dispatched to make a detailed investigation. The local manager and foreman expressed their regret that the accident had occurred, and added that the accident was purely the fault of the injured, not giving thought to any responsibility that might rest on them. It developed in the investigation that the employe was killed when he was installing some lightning arresters on a pole in the distribution system. His knee came in contact with an unprotected ground wire and his arm with a hot primary. He fell back in his safety belt lifeless from the effects of the shock. He was lowered to the ground and died simply because of the ignorance and incompetence on the part of his comrades in not knowing the proper method of resuscitation.

In the first place, the victim was not installing the arresters in accord with specifications of the company engineer. His not doing so was no deliberate violation of the rule on his part, as it was found that the foreman had not acquainted his men with such specifications. In the second place, he was not wearing rubber gloves in handling energized primaries, which is a universal rule throughout this particular company. When questioned as to why he had not required that this be done, the foreman said some of his men had been doing similar work previously, and he had left it to their good judgment about wearing the gloves, and if they got hurt it would be their fault. In the third place, the two other employes who were present at the time of the accident did not know how to revive the man. When questioned on this score, the foreman said that these men had been employed only 15 days, and while he knew that it was a standard rule with the company that the foreman should teach the new man the Prone Pressure Method of Resuscitation before he assumed any of his duties, yet he

had been so busy that he just did not have time and had put it off till a later date. The removal of any one of these three causes might have saved the man's life, and each remedy certainly was not only within the bounds of jurisdiction of the foreman, but should constitute the elementary principles of a foreman's duties. The fundamental causes of this accident were lack of proper instruction and violation of rules, the result may be classified under electricity, while the effect was death to the employe. Does it not appear, therefore, that the prime need is a correct diagnosis, and that the proper knowledge of causes usually carries implicitly a suggestion of the cure?

Falls from Poles

A gaff in a climber has been used so long that it becomes short. It is not long enough to penetrate through the rotten sap ring of the pole and secure a good hold, and down comes a lineman. Even as small an item as an improperly sharpened gaff has caused a fatality. If the gaff has a curved surface at the point and, when a lineman comes down a pole, if the curved point hits a tack, nail head, or hard knot, the tendency is to throw the foot out and the knee in toward the pole with the great possibility of a fall.

Electricity

Seventy-eight deaths and 36,023 actual days lost from work during 1922, resulting from electric shock, burns and flashes are figures that are staggering, more especially so when we consider that they represent only 119 companies. The fundamental reasons for these accidents are many. Some are due to the lack of providing and enforcing standard safe operating rules. In the larger cities, accident experience has caused the establishment and enforcement of certain safety rules. Many companies which operate in the smaller cities, and some companies which operate strings of properties throughout the country, do not have many safety rules in effect. Management must first issue such vital safety instructions, which if adhered to will tend to eliminate the greater volume of accidents. These must be "hide bound" to secure results. In some companies even where safety rules are in effect, the failure to enforce them is the direct cause of many accidents. It is rather peculiar, too, when we think of the times when workmen have been fired because of lack of respect for the dignity of the boss, and then not even reprimanded because of the more important matters of violation of operating or safety rules.

A cure for many an accident may be found among the following rules. With some modification, possibly, to fit local conditions, these should be in effect universally and made mandatory, regardless of the size of the company.

(a) The wearing of rubber gloves when handling energized wires or apparatus carrying a voltage between 300 and 5000.

(b) The placing of danger signs and "hold" cards on all switches which are opened to permit work to be done on lines or apparatus and the repeating of the switching orders when given. (This rule is violated quite frequently in the smaller stations and has resulted in many accidents.)

(c) The treating of street lighting circuits as energized primaries at all times.

(d) The use of grounding clamps and cable as a supplementary measure in conjunction with chains for protective grounding of high tension lines and apparatus.

(e) The universal rule of making it the first duty of a foreman to teach each new man the prone pressure method of resuscitation before that new man assumes any of the duties, and to follow this up with periodic practice to see that he becomes proficient in his knowledge of it. (This need not necessarily apply to temporary laborers.)

Specific remedies possibly cannot be offered for the elimination of all electric accidents, because they do not all happen alike. Furthermore, a great number are charged to human failure, either on the part of the workman or his supervisor, rather than improper design or insufficient mechanical guarding of apparatus. Consequently, we must get some insight into the personal element.

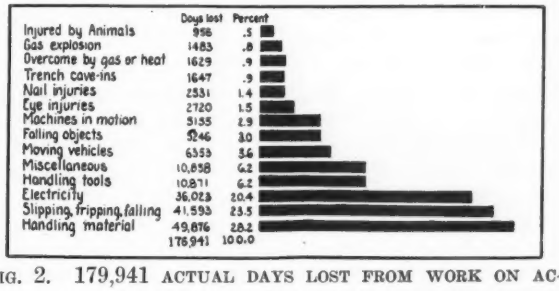


FIG. 2. 179,941 ACTUAL DAYS LOST FROM WORK ON ACCOUNT OF ACCIDENTS ANALYZED AS TO IMMEDIATE CAUSES

Typical Cases

An employe placed a ladder against the side of a station wall and climbed up to clean a window. He came in contact with a 15,000-v. bare conductor and part of the grounded frame work. He could have opened the disconnectors in this circuit without interrupting service—but he didn't.

A patrolman at an isolated switching station had occasion to do some work on a piece of equipment a short distance away. He opened the switch to kill the circuit but didn't tag it. A power customer, whose service was interrupted, called to the dispatcher, who ordered another employe to close the switch. The employe working on the apparatus was badly burned and lost 6 mo. from work.

Another employe climbed one of the poles of a substation switching structure and without glancing above to see what he was climbing into, his head came in contact with a 33-kv. disconnecting switch and, even though he was resuscitated, the injuries received caused 10 mo. lost time. Clearly such accidents are due to the "human element." Many similar accidents involve a mental cause which it will pay to study.

Possibly another need in the utilities industry toward accident prevention is some kind of scheme to impress on the new workmen continually during the learning period the importance of forming safe working habits so that he will not be so susceptible to injury during later years. Certainly, we all agree that in our industry there are a greater number of deaths among the older men in point of service, and some of his fellow workmen usually make such statements as "he was one of the most careful men on the job" after an accident has happened.

Possibly a good working habit formed early in his beginning days would have prevented the accident.

This type of accident may be charged to "poor judgment" on the part of the injured, but something must be done to better his judgment. It may appear theoretical, but apparently the only solution possible is to train each workman at the beginning so he will work safe habitually, and even though his mind may become distracted or inattentive about some tedious and dangerous work in hand, thinking possibly of some domestic trouble, a financial difficulty, or some recent event, the safe working habits he has formed will have quite a good mechanical effect and possibly keep him from getting hurt.

Sometimes workmen are hired in the presumption that somewhere they have been thoroughly trained, and so are left to follow their own inclination. Sometimes they are given a set of rules to follow, but a check up is never made to see that they are being followed to the letter. Perhaps the foreman may speak a word on safety as he details some jobs the new man must do, and that is about all. Safety instruction given the first day is wasted unless it is repeated a good many times.

Boiling down all these facts so that they may be applied to individual companies, there are two vital remedies. These remedies are practical, for they have already been thoroughly tried out and proven successful in a number of large companies. The first of these is the suggested remedy and its application that results from an exhaustive investigation of an accident. This covers a "multitude of sins." It includes principally the determination of the fundamental cause, fixing the responsibility, promulgating new rules, and the executive backing which is ofttimes essential and which carries great weight.

The second is the medium through which the majority of these may be woven into the industry. This certainly is the foreman's responsibility, the scope of which might include the entire field of training the workmen, the solicitation of safety help from the workman, the anticipation of accidents on the job, the issuing of special instructions for the varying conditions encountered, and the enforcement of rules in effect.

Cleaner for Brass Electrical Parts

By G. A. Luers

WHEN assembling electrical parts as magneto, generator or motor contacts, the pieces should be clean and bright to assure electrical conductivity. The use of a file, scratch brush or sandpaper, involves much time and patience with the result that the mechanic is more likely to assemble parts without cleaning, taking a chance that the work will be successful in operation.

A method which one mechanic uses regularly in cleaning parts before assembling, is to dip the parts into a bath. This dipping bath cleans instantly; it consists of a half pint sulphuric acid, half pint nitric acid and two tablespoonfuls of salt. The articles are dipped into this solution and immediately rinsed in water. The old corroded parts are made as bright as new and when assembled the worker is assured that the essential electrical contact is made in the parts of the mechanism.

Chart for Determining Expansion Loop Data

By Dwight Gerber

IN LAYING out piping in which expansion loops occur, it is convenient to have at hand a ready means of determining the footage of pipe necessary to form a bend. The chart displayed herewith will be found useful for this purpose. By means of it, not only the footage of pipe necessary to form a bend, but also the overall clearance dimensions may be read direct for any diameter of pipe formed to a recommended or standard, minimum or extreme radius.

It will be noted that the group of curved lines along the left-hand border of chart, marked "Pipe Sizes,"

TABLE I. BEND FACTORS

PIPE SIZE	TANGENT ENDS			RADII					
	SC'D	WELD	LAP	STANDARD		MINIMUM		EXTREME MINIMUM	
				RAD.	ARC.	RAD.	ARC.	RAD.	ARC.
	T	T	T	R	90	R	90	R	90
1	2¼	2¼		7	0′11″	2¼	0′ 3⅛	2″	0′ 3⅛
1¼	2½	2½		8	1′ 0⅛	2¾	0′ 4⅜	2½	0′ 3⅛
1½	2¾	2¾		10	1′ 3⅛	3¼	0′ 5⅛	3	0′ 4⅛
2	3	3		1′0	1′ 6⅞	4½	0′ 7⅛	4″	0′ 6¼
2½	4	4		1′2	1′10″	6	0′ 9⅛	5″	0′ 7⅞
3	4	5	6	1′6	2′ 4¼	7	0′11″	6	0′ 9⅛
3½	5	5	6	1′8	2′ 7⅜	9	1′ 2⅛	8	1′ 0⅛
4	5	5	6	2′0	3′ 1⅛	1′0	1′ 6⅞	10	1′ 3⅛
4½	6	5	6	2′2	3′ 4⅞	1′3	1′11⅛	1′0	1′ 6⅞
5	6	5	7	2′6	3′11⅛	1′6	2′ 4¼	1′3	1′11⅛
6	7	6	7	3′0	4′ 8½	2′0	3′ 1⅛	1′6	2′ 4¼
7	8	6	8	4′0	6′ 3⅜	2′4	3′8	1′9	2′ 9
8	9	6	8	4′6	7′ 0⅛	2′8	4′ 2¼	2′0	3′ 1⅛
9	11	6	9	5′0	7′10¼	3′6	5′ 6	2′3	3′ 6⅝
10	12	7	10	5′6	8′ 7⅛	4′0	6′ 3⅜	2′6	3′11⅛
12	14	7	10	7′0	11′ 0	5′0	7′10¼	3′0	4′ 8½
14	16	7	14	8′0	12′ 6⅞	6′0	9′ 5⅛	4′0	6′ 3¾
15	16	7	14	9′0	14′ 1⅝	6′6	10′ 2½	4′6	7′ 0⅛
16	18	8	16	10′0	15′ 8½	7′0	11′ 0	5′6	8′ 7⅛
18	18	8	18	11′0	17′ 3⅝	8′0	12′ 6⅞	6′6	10′ 2½
20	18	8	18	12′0	18′10¼	9′0	14′ 1⅝	8′0	12′ 6¾
22	18	9	20	14′0	21′11⅞				
24	18	9	20	15′0	23′ 6¾				

TABLE II. DEGREE AND MINUTE CONSTANTS

FOR ARC LENGTHS
RADIUS BEING 1

DEG.	CONS'NT	DEG.	CONS'NT	DEG.	CONSTANT	MIN.	CON'NT
1	.0175	41	.7156	81	1.4137	21	.00610
2	.0349	42	.7330	82	1.4312	22	.00639
3	.0524	43	.7505	83	1.4486	23	.00669
4	.0698	44	.7679	84	1.4661	24	.00698
5	.0873	45	.7854	85	1.4835	25	.00727
6	.1047	46	.8029	86	1.5010	26	.00756
7	.1222	47	.8203	87	1.5184	27	.00785
8	.1396	48	.8378	88	1.5359	28	.00814
9	.1571	49	.8552	89	1.5533	29	.00843
10	.1745	50	.8727	90	1.5708	30	.00872
11	.1920	51	.8901			31	.00901
12	.2094	52	.9076			32	.00930
13	.2269	53	.9250	Constants for each Minute		33	.00959
14	.2443	54	.9425			34	.00989
15	.2618	55	.9599			35	.01018
16	.2793	56	.9774			36	.01047
17	.2967	57	.9948			37	.01076
18	.3142	58	1.0123			38	.01105
19	.3316	59	1.0297	MIN.	CONSTANT	39	.01134
20	.3491	60	1.0472			40	.01163
21	.3665	61	1.0647	1	.00029	41	.01192
22	.3840	62	1.0821	2	.00058	42	.01221
23	.4014	63	1.0996	3	.00087	43	.01250
24	.4189	64	1.1170	4	.00116	44	.01279
25	.4363	65	1.1345	5	.00145	45	.01309
26	.4538	66	1.1519	6	.00174	46	.01338
27	.4712	67	1.1694	7	.00203	47	.01367
28	.4887	68	1.1868	8	.00233	48	.01396
29	.5061	69	1.2043	9	.00261	49	.01425
30	.5236	70	1.2217	10	.00290	50	.01454
31	.5411	71	1.2392	11	.00319	51	.01483
32	.5585	72	1.2566	12	.00349	52	.01512
33	.5760	73	1.2741	13	.00378	53	.01541
34	.5934	74	1.2915	14	.00407	54	.01570
35	.6109	75	1.3090	15	.00436	55	.01599
36	.6283	76	1.3265	16	.00465	56	.01628
37	.6458	77	1.3439	17	.00494	57	.01658
38	.6632	78	1.3614	18	.00523	58	.01687
39	.6807	79	1.3788	19	.00552	59	.01716
40	.6981	80	1.3963	20	.00581	60	.01754

are crossed by three vertical lines, marked "Standard, Minimum and Extreme Minimum Bend Radii." To use chart in determining the factors for a 10-in. diameter, extra heavy pipe, formed to a recommended minimum radius: Follow the curve marked 10-in. pipe to the intersection with the vertical line marked, "Minimum Radius," thence along guide lines horizontally to the intersection with the long diagonal line, thence down to the scale and read 37.7—footage of pipe required to form the bend.

power station, all data at hand must be considered more or less approximate until practical tests performed under actual working conditions have been recorded.

Exhaustive tests have shown that the allowable unit fiber stress in pipe material should not be taken in excess of, say, 7000 lb. per sq. in., to be safe and at the same time reduce the force required at the anchorage points that are required to make the bend flex.

This consideration is particularly important in the calculation of bend used to protect turbo generating

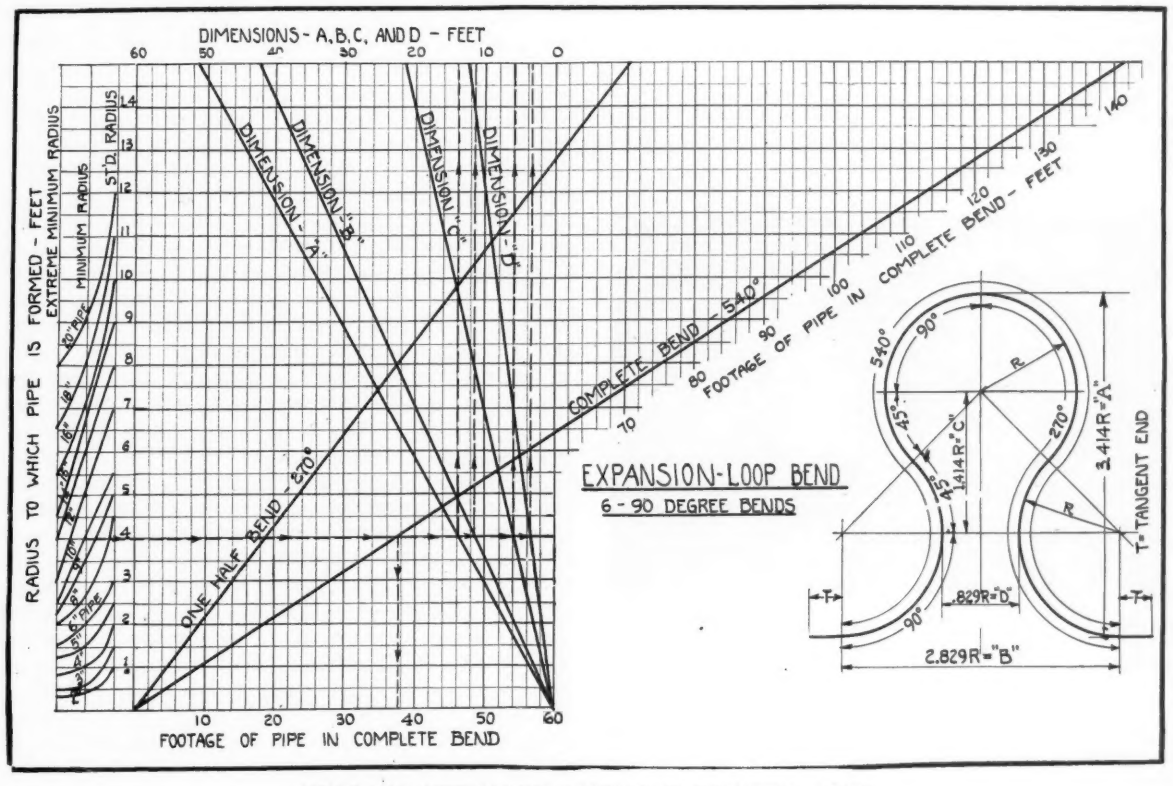


CHART FOR DETERMINING FOOTAGE OF EXPANSION LOOPS

For dimensions A, B, C and D traverse the same guide lines to the intersection with inclined lines marked "Dimensions A, B, C and D, thence up to the scale along upper border of chart, and read 13.7, 11.3, 5.7 and 3.3, the values for these dimensions respectively. The natural function constants, necessary to determine each of these dimensions, evaluated with radius R, are given on the figure, so that the exact value may be used for work. The approximate value, as read from the chart, however, is sufficiently accurate to be used in determining clearances. Convenient bend factors are shown in Tables I and II.

Relevant to the considerations embraced by this chart, is the frictional resistance offered to the flow, by this particular type of bend, which containing the equivalent of six square bends, will offer a resistance equal to that of a straight pipe, 240 pipe diameters in length. The amount of expansive movement that will be cared for by such a bend is also important. Much has been written in discussion of this feature, but due to the rapid breaking down of the tensile qualities of wrought pipe material under temperatures approximating 700 deg. F., usually found in the present day high duty

units against expansive movement in the steam lines which connect them. While the generating units have increased in capacity, the size and weights of metal section have decreased, as compared to the connecting steam lines.

DIMINUTION of the nation's gasoline stocks on Sept. 1 to a figure of 1,053,856,221 gal., representing 47 days' supply, as compared with a stock of 1,165,389,340 gal., or 54 days' supply, on hand Aug. 1, was announced by the Department of the Interior recently, from statistical data compiled by the Bureau of Mines. Gasoline stocks Sept. 1 of last year amounted to 703,738,310 gal., or 37 days' supply.

Output of gasoline in August was 648,954,706 gal. as compared with 637,000,000 gal. in July and 550,000,000 gal. in August, 1922. Domestic consumption during August amounted to 692,185,610 gal., an increase of 18,000,000 gal. over the July consumption and an increase of nearly 109,000,000 gal. over August of last year. Exports of gasoline in August were 78,503,475 gal., a decrease of 5,000,000 gal. from the July figures, but an increase of 50,000,000 gal. over August, 1922.

Tepexic Plant in Mexico Is Completed

Two 620-ft. Head Reaction Turbines Installed in New Mexican Light & Power Co. Plant. By Charles W. Geiger

ELECTRIC ENERGY for the City of Mexico, for the mines of El Oro, and for the nearby communities is supplied from the system of the Mexican Light & Power Co. The principal supply comes from hydroelectric plants on the Necaxa River, about 125 mi. northeast of Mexico City, a steam station in the city itself being maintained principally for standby service. The Necaxa River and its tributaries flow through a rugged mountainous country with a humid climate, and the power possibilities are almost unlimited. The company's plan of development calls for a construction program extending over a long period, additional plants being scheduled as the market for power increases.

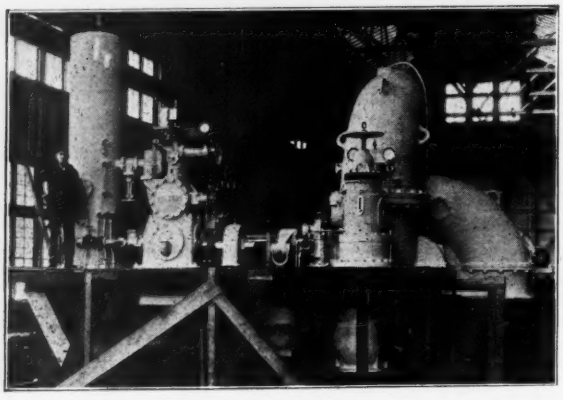


FIG. 1. COMPLETE SHOP ASSEMBLY OF TURBINE, GOVERNOR AND OIL PRESSURE SYSTEM

Work was commenced in 1907, with the construction of the Necaxa dam, one of the highest earth dams in the world, together with other storage works, and the erection of the Necaxa power house. As originally constructed, the plant comprised six 5000-kw. generators driven by vertical impulse wheels having two nozzles each, and operating under a head of 1250 ft. Both wheels and generators were of European manufacture. Additional equipment was installed later, bringing the total capacity of the plant up to 50,000 kw.

To meet the increasing demand for power, construction was commenced in 1922 on the second unit of the company's program, the Tepexic power house, on the Necaxa River. Water is diverted just below the tailrace of the Necaxa plant and is carried in a concrete-lined tunnel to a sand trap and thence to a surge-tank directly above the Tepexic site. Two 72-in. Venturi meters are placed between the surge-tank and the pair of gate-valves regulating the flow through the penstock. These valves are electric motor operated and are arranged for both direct and remote control from the power house. They may also be operated by hand.

For a distance of about 1400 ft. from the surge tank, the penstocks are on a relatively gentle slope, and the inside diameter is 72 in. The slope then becomes steeper, about 45 deg. for most of the remaining distance, and the diameter of the pipe is gradually reduced to 63 in. at the power house.

Between the lower end of each penstock and the butterfly valve controlling the flow to each turbine, adjustable erection joints are placed. These joints are of the expansion type and are so constructed as to permit the two sections to telescope into each other for several inches. Besides facilitating the erection work, the use of such a joint also permits dismantling the butterfly valve without disturbing any other part of the equipment.

Each of the two main generating units comprises a Pelton horizontal single overhung reaction turbine driving a General Electric 13,000-kw., 50-cycle, 600-r.p.m. generator through a direct connection. The generators have a continuous overload capacity of 15 per cent, or a total of about 15,000 kw. The turbines develop 17,500 hp. under normal load, with a maximum capacity of 20,000 hp., under a normal effective head of 620 ft. The exciters are each mounted on an extension of the main shaft. The two turbines are identical in construction, and each is provided with a 66½-in. butterfly valve, arranged either for electric motor or for emergency hand operation. The mechanism for both types of operation is located on the main power house floor. The motor-operating mechanism can also be arranged for remote control at one or more points. Over travel of the operating mechanism is prevented by limit switches.

Each runner is of bronze, cast in one piece, so designed as to insure hydraulic balance at all loads, but a thrust bearing of the Kingsbury type is provided on the outboard end of the main shaft to care for any unbalanced thrust load that may arise because of accident. This bearing is adjustable in three dimensions, a feature that is particularly desirable because it permits rapid and accurate centering of the runner during erection. The thrust bearing housing is rigidly attached to the outboard bearing pedestal.

Both the runner and the casting covers are equipped with removable and renewable clearance rings. The single overhung construction of the runner facilitates replacement of either these rings or the runner, since the draft-elbow may be removed and the turbine entered without disturbing either generator, shaft, or bearings. Furthermore, since the entire regulating mechanism is outside the casing on the generator side it can also be left in place. This feature also permits the ring casing cover to be removed from the outboard or draft-tube side of the turbine, and all the wicket-gates taken out without disturbing either the shifting ring or the connections to the governor rockshaft.

The gate-shifting links are purposely made the weakest part of the connection between the governor and the guide-vanes. Such a design insures that in case of obstruction to the quick-vanes, a shifting-link will break, rather than some more expensive and less easily renewable part of the apparatus. Should accident to either the governor or the operating mechanism occur, the gates are so balanced that they drift slowly to a nearly closed position, remaining sufficiently open to prevent shocks to the pipe-line.

The main shaft is supported by two Pelton, ring-oiling, self-alining generator type, water-cooled, ped-

estal bearings, of such liberal proportions, as to limit the unit pressures to a low figure. The oil reservoirs are of sufficient size to insure cooling of the bearing under normal operating conditions. To provide, however, for such emergency conditions as may arise, labyrinth passages are provided to permit continuous water circulating for cooling the lubricating oil. Both shells and bearings are made in halves, to permit easy access to the interior of the bearing.

Each turbine is controlled by a governor of the Pelton vertical-spindle, belt-driven, actuator type. The actuators are equipped with enclosed centrifugal elements and dashpot compensation. The following special equipment is provided in connection with each governor:

1. An automatic runway device, which will shut down the entire turbine in case of accident to the governor flyballs or breakage of the driving belt.
2. An adjustable load-limiting device, which may be set so as to limit automatically the load carried by either turbine to any desired amount.
3. An emergency shutdown device, by which the plant may be shut down by hand, by means of the pilot-valve, using governor oil pressure, without disconnecting the actuator or affecting its previous adjustment.
4. A device for controlling the actuator from the switchboard, consisting of a direct-current motor, mounted on a bracket attached to the governor and connected by gearing with the speed-control mechanism.
5. An auxiliary hand-control mechanism using pressure oil, but independent of the main governor and its servomotor. A single movement of a lever disconnects the actuator and throws in the hand control.

Although the servomotor capacity is sufficient to permit a full stroke of the governor in three seconds, the actuator may be adjusted, if desired, to provide for a longer time of stroke, or for different periods for the opening and the closing stroke.

Each oil-pressure set comprises a sump-tank, a tank for pressure oil, and a rotary pump driven by a Pelton impulse wheel. The capacity of the pressure tank is sufficient for several full strokes of the governor in case the pump is rendered temporarily inoperative. The quantity of oil in the tank is controlled automatically, a float control shutting down the pump when the oil reaches a certain level, and starting it again when it drops materially below that level.

Each turbine is equipped with a needle-type positive opening relief valve. A study of the hydraulic conditions indicated that a capacity equal to 70 per cent of the maximum capacity of the turbine would be adequate for protection of the pipe line, so this size was selected. For any material load rejection the valve opens directly and instantaneously with the closure of the guide vanes, and closes slowly, so as to prevent water ram in the pipe line. The rate of closure is controlled by an oil dashpot, which may be adjusted to give any desired length of stroke. The mechanism may be adjusted so that in case of load rejections too small to affect pipe line pressures objectionably, the relief valve will not open at all, thus avoiding any unnecessary use of regulating water.

The guarantees by the turbine manufacturers were: maximum efficiency, 89 per cent; efficiency at normal load, 88.5 per cent; maximum momentary speed rise with full load rejection, 22 per cent; maximum momentary pressure rise with full load rejection, 30 per cent.

Including butterfly valve, relief valve, governor, etc., the total weight of each turbine is about 250,000 lb. The heaviest single piece is the upper half of the casing, since the lower half is in two pieces. The upper half weighs nearly 25,000 lb.

Turbines, governors, and butterfly valves were manufactured at the San Francisco works of the Pelton Water Wheel Co. The generators were furnished by the General Electric Co., and the penstocks and adjustable erection joint by the Ferrum Co.

A standard gage line, a branch of the Mexican National Railway, extends to Beristain. At Beristain, all material was transferred to a narrow-gage line running by way of Necaxa to a point directly above the Tepexic plant, about 25 mi. from Beristain. From this point a tramway was constructed parallel to the penstocks down to the power house. Machinery and other material was lowered down this tramway by means of winches. The grades were steep, about 45 deg. for most of the distance.

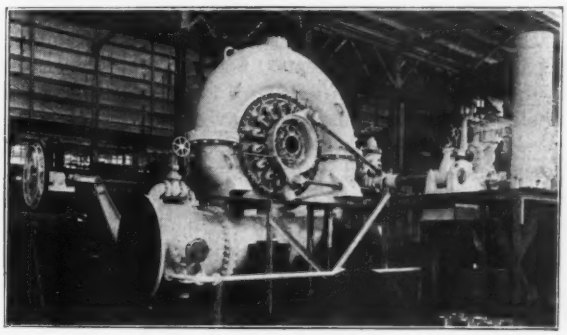


FIG. 2. SHOP ASSEMBLY OF UNIT SHOWING GATE OPERATING MECHANISM AND BUTTERFLY VALVE

The construction of the entire project was under the general direction of G. R. G. Conway, managing director for the Mexican Light & Power Co., with headquarters at Mexico City.

Steam from Nature's Boiler Harnessed for Power

IN QUEST for cheaper power, engineers have long been engaged in attempts to shackle the earth's internal energy. Experiments are being conducted in a region called the Hot-Belt of northern California and Nevada, to learn the possibility of harnessing the steam that is there generated. By drilling into the ground a pressure of from 30 to 70 lb. has been obtainable at the surface.

Already one engine is using underground power and experts expect to pipe this low cost energy over a large territory. Electrification of railroads in that territory and extraction of carbonic gas from the steam for preserving shipments of fruit are regarded as future steps. Since 1904, northern Italy has been supplied with electricity produced by engines driven by such underground steam power. C. R.

IT IS POOR economy to install cheap and unreliable instruments in a plant. It would be better to have no thermometer or gage at all than to have one that is unreliable.

Use of Graphic Instruments in Power Plants

WITH the tremendous development in the field of power plant engineering in recent years, there has come about an increased demand for accurate records and operating data. Graphic instruments play an important part in recording such data and the use of each instrument for the purpose is becoming more and more common. In a recent bulletin published by the Esterline-Angus Co., the more important uses to which recording instruments have been applied by power companies, are outlined.

In the boiler room, for instance, many power companies have installed graphic wattmeters which record the total load in the stations. This is done for the purpose of giving the operator the trend of the load, enabling him to predict when boilers on the line should be increased or decreased as the load increases or decreases. These wattmeters can be supplied for any required capacity, the only requirement being that the generating equipment be in synchronism. In some cases, a special totalizing current transformer having a single secondary winding and a number of primary coils is used. Another common method is to use a wattmeter of high current capacity, and parallel the secondaries of the required number of current transformers, all of the same primary capacity and placed on several circuits.

In Generator Room and Sub-Stations

Records of voltage, frequency, power factor and kilowatts are those most commonly demanded at the station switchboard and in sub-stations, the grouping of the instruments depending upon the size of the plant and the layout of the distributing system. In many plants, a graphic wattmeter and power factor meter are provided for each main feeder, with a totalizing wattmeter, frequency meter and voltmeter for the main busses.

An interesting record is obtained by using the totalizing and feeder wattmeter record charts over again each year, changing the color of the ink. Starting, say, on the first Monday of the year, the same record chart used for the same period of the year previous is used, and by using different colors of ink, a comparison of station and feeder loads is obtained for the corresponding day of succeeding years, which is both valuable and interesting.

With an increasing number of central stations it is now the practice to arrange the station graphics so that the speed of the chart feed is increased 60 times normal, in case there is an excessive overload or trouble on the system, so as to get legible records of what transpires in cases of trouble.

On the Distribution System

In obtaining records on the distributing system the practice varies. Some companies install permanent instruments wherever possible, in sub-stations and at outside points on the system, to obtain voltage and kilowatt data, using portable instruments where permanent installations are not feasible. Others make periodic tests with portable instruments together.

Such a systematic survey of the distributing system makes possible an intelligent plan for growth and extension, forestalls the overloading of transformers and feeders, and shows up incorrect voltages on the system.

In Power Sales

In central station practice, the most desirable class of business is usually the most difficult to obtain, and graphic instruments, in the hands of the power salesman, are the means of obtaining just the information necessary in order to analyze the customer's requirements, to pre-determine his power cost and to fix the capacity of the installation.

Investigations and Reports

It is the practice of many central station engineers to use graphic instruments for obtaining their data in investigations of various kinds, such as rates, extensions, electrolysis, proposals to import-consumers, power factor correction, etc. Data obtained in this manner can be taken over a sufficient period to insure their being representative, accuracy is assured, and a report containing prints of the record charts carries conviction and is much more easily comprehended than long columns of figures, with their totals and averages.

In the Meter Department

Many power companies use portable graphic wattmeters for determining the maximum demand charge for certain classes of customers. Instead of installing a demand meter permanently, a graphic test is made once or twice a year, and on this the demand charge is based. Where a power factor charge is made, records of power factor are made at the same time. Quite a number of companies install a graphic wattmeter permanently on the lines of large and important customers; especially is this true where the rate charge covers instantaneous peaks. Such an instrument gives the demand, the peaks, the records of interruptions to service, as well as the character of the load.

Results of tests of a power plant at Rivermines, Mo., using pulverized coal as a fuel, are given in Technical Paper 316, just issued by the Department of the Interior through the Bureau of Mines. The tests, which comprised two boiler tests, six drier tests, and eight mill tests, were made by the fuel section of the Bureau of Mines, in co-operation with certain engineering firms. The boiler tests were made on two Stirling boilers, each having 7688 sq. ft. of heating surface.

Coal used in these boiler tests was weighed as delivered to the preparation plant and before being pulverized. As the coal was passing through this plant, tests were also made of the drying and pulverizing units for the main object of determining the capacity of these units and the power they consumed. During each of the drier and mill tests, 100 to 300 T. of coal was dried or pulverized. Bituminous coal from southern Illinois, of good quality for that district, was used. It was shipped as screenings, and the part delivered to the powdered-coal plant contained little slack. The results of the boiler tests are exceedingly good when compared with stoker performance under similar conditions.

Technical Paper 316, by Henry Kreisinger, John Blizard, C. E. Augustine, and B. J. Cross, may be obtained from the Department of the Interior, Bureau of Mines, Washington, D. C.

Non-Return Valves Save Engine

In our plant, the exhaust piping is so arranged that the plant can be operated either condensing or non-condensing; in the latter case, the exhaust is used for heating purposes. Recently an accident occurred which proved the value of non-return valves on the exhaust line and indicated the desirability of duplicate exhaust heads and back pressure valves.

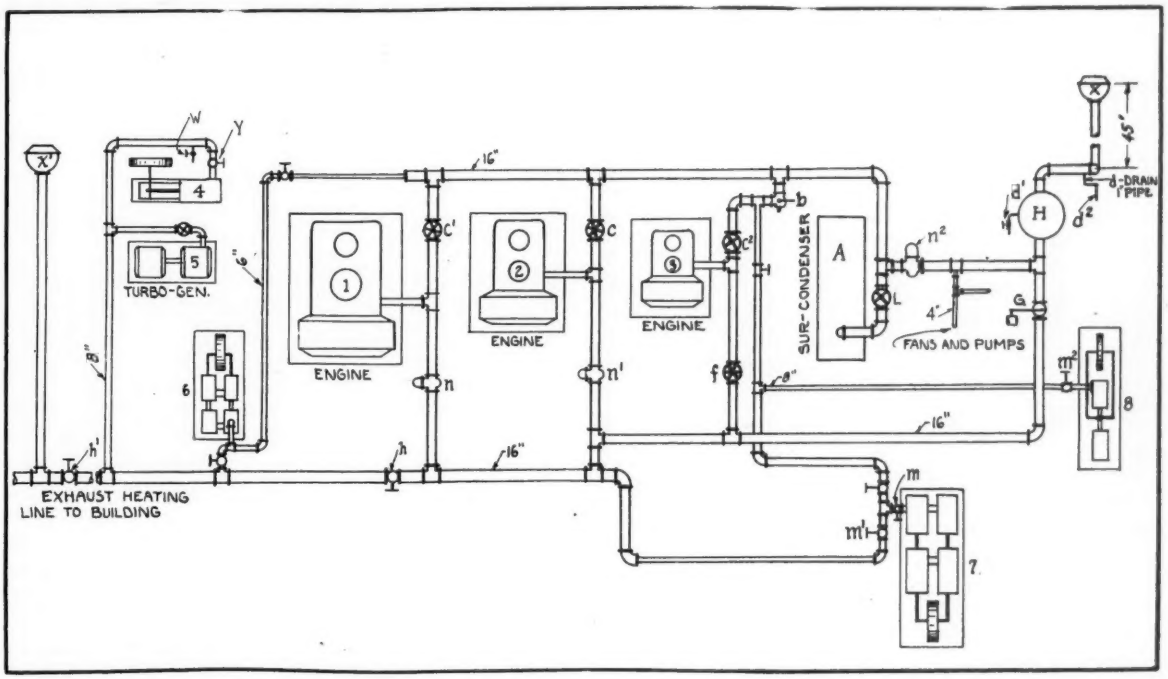


FIG. 1. LAYOUT OF PLANT SHOWING ARRANGEMENT OF EXHAUST LINE WHICH WAS FLOODED

Figure 1 shows the arrangement of the power plant and the 16-in. exhaust pipe line which was flooded; (1), (2) and (3) are vertical compound engines, and (4) is a single cylinder engine, all direct connected to generators; (5) is a direct connected turbine unit; (6) and (7) are compound two-stage air compressors; (8) is a simple, single-stage compressor; (A) is a surface condenser and (H) a vertical heater, 30 in. in diameter. Valves (n), (n^1) and (n^2) are automatic, non-return, out-port atmospheric relief valves, and (g) and (a) are weighted back pressure valves. (B) is a 2 in. open end stop cock for breaking the vacuum; (C), (C^1) and (C^2) are stop valves on the condenser line.

The plant had been stopped for the day except one engine (2) and a compressor (7) which were running overtime. All went well until just before 9 p.m., when there were slight sounds of water hammer from the night lights. It was exhausting around through valve n. Valve n^1 was closed. This engine is only 45 hp. and was carrying only 100 amp. load. The throttle on No. 2 engine was closed and the drips and the vacuum breaker (B) had been previously opened.

I proceeded to close valve (C) to cut the engine off the condenser line. There was considerable hammer and rattle of valves which was usual in such case of no vacuum, but this was getting more severe each pound, and then a shot of water followed by exhaust steam spurted from the 2-in. vacuum breaker. The pumps and fan engines were exhausting into the line at (2). The throttle on No. 2 engine sometimes leaked, but my first thought was that the air pump on the condenser had failed and flooded the condenser, and to keep the water from the engine I closed valve (C) with all haste, and then, as if Satan had turned all his imps loose at once, everything seemed suddenly to become a mass of rattling, hammering, shaking pipes.

The water should have flowed away from the condenser by gravity, but as there was no time to stop to dope out the cause, I shut the valve (L), shutting the exhaust line off the condenser, but could not open the out-port relief (n^2), which had a lever on it. The water hammer had ceased to a great extent at the other end of the station, and had become a rumble in the heater (H) and exhaust pipes in the corner. The condenser had been shut down. Evidently the trouble was in the heater, or the valve (n^2) could have been opened easily.

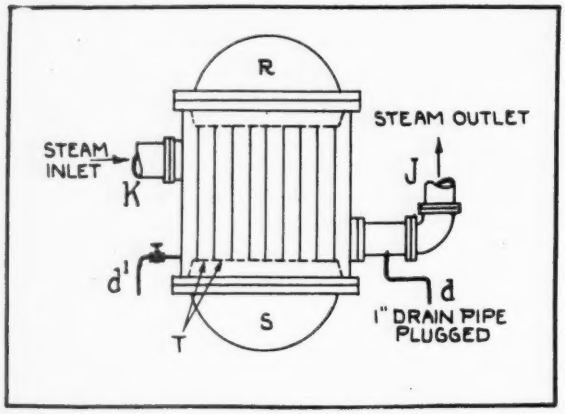


FIG. 2. CLOSED FEED WATER HEATER WITH STRAIGHT TUBES

With water on top of it, it could not. I went hunting for a drain pipe and for the fireman; he had just discovered that the water was getting low in the boilers. With this heater jumping up and down and rumbling, we opened the bypass and cut the heater out of service, feeding direct through the economizers. It was the exhaust steam from the auxiliaries entering the heater which was causing the rumble and hammer now, and there was no way to divert it from the heater. It was evident that the heater tubes had burst, but why would the water not drain out. I looked to the open end of the drain pipe (d), a 1-in. pipe, and tried the drain valve (d^1) from the heater. It was open. Someone had added a piece of pipe (d^2) to the drain to take it into the catch basin on the floor so it was not easily seen. It was plugged up at (d) and that 16-in. exhaust pipe must have been full of water up to the head for, instead of 150 lb. pressure on the feed line, we had only 50 lb.

I cleared the plugged nipple with a wire and the water came out with great force. This emptied the heater and exhaust pipe outside of valves (n^2) and (g), while valve (g) kept the water from the heater from flowing back into the atmospheric exhaust pipe. It could not open to allow the exhaust from No. 4 engine to escape, a pressure was built up in the pipe and the condensate accumulated and held valve (n^1) shut, causing the water to surge back and forth through the pipe, hammering at the elbows, and at one time lifted the valve (g) (this was when the heater began to jump up and down). There was no time to close the drains on No. 4 engine; lucky there was not for the exhaust pipe had a 1½-in. drain pipe (w) and through this pipe enough steam escaped to prevent the exhaust pressure reaching a dangerous limit.

The opening of the back pressure valve (g) was due principally to the force of the water hammering against it with great velocity, more than to the steam pressure. Y is the exhaust stop valve on No. 4 engine which was open at the time, X^1 is the exhaust head from an auxiliary engine, and h^1, a stop valve to separate it from the heating main, h^1 being closed. Had valve g been open at the time the heater tubes gave out, the exhaust main would have been flooded back as far as valve h^1, as the drains of this line could not have taken care of the condensate and the water from a 2½-in. discharge pipe from the feed pump, running at full speed.

The heater, Fig. 2, had straight through, end to end, 1-3/16 in. outside diameter corrugated copper tubes, expanded into the ends. The spherical heads (R) and (S) were divided into three compartments so the feed water passed the length of the heater three times before going to the economizers. At first sight the repair did not look like a big job. The top and bottom heads could be easily removed, but the steam from the auxiliaries, entering the heater, all passed through the heater to exhaust head (X) and, of course, kept the heater hot and escaped through the leaking tubes to bother the

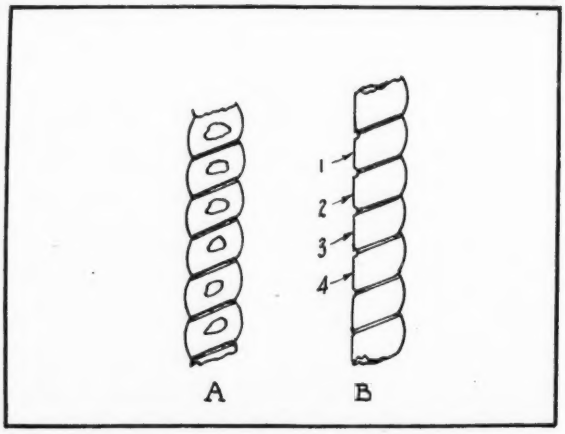


FIG. 3. PIECES OF CORRUGATED TUBES TAKEN FROM HEATER

workmen. Accordingly temporary exhaust lines were run from the auxiliaries out doors, so that while the plant was running condensing, the men could work on the heater. As exhaust steam spurted from one tube, it was cut out and revealed the cause of the trouble.

In Fig. 3, B is a side view of one of the tubes which was bent, and the pulsation of the exhaust steam had caused it to vibrate and rub against the others until it had worn through the metal of the corrugations, as at 1-2-3-4, leaving holes as seen in part A. The other leaky tubes were not so easily detected, and a test of all the tubes had to be made. A pair of caps was made to fit over the ends of the tubes and a rod, run through, bolted them together. A ⅜-in. pipe was attached to the bottom cap and a ¼-in. test gage and pet cock attached to the top cap, as shown in Fig. 4. Water pressure was turned in at the bottom from a feed pump, while the air escaped through the pet cock at the top; then the pet cock at the top was closed and the pressure run up to that on the pump gage when the valve from the pump was closed. If the gage at the top of the tube did not drop in pressure the tube was sound and tight. In this manner, all the tubes were tested and only three found to be leaking.

Corrugated copper tubes could not be obtained, and so a 1-in. steel pipe was substituted, cut to the right

length, turned at the ends in a lathe and annealed before being put in. A special tube expander was made in the shop for the job.

There is much to be considered when selecting the type and location of a heater to be used on a condensing system. It has been my belief that a closed heater should always be placed between the engine and the condenser, allowing all the exhaust steam to pass through it, thereby extracting as much heat from the steam as possible before it enters the condenser, thus saving the condenser from handling any more condensing water than is absolutely necessary. It appears, however, from this accident that heaters having straight, end to end tubes, with steam entering at the sides, as at K, and exhausting at J, are subjected to tube vibrations from the ex-

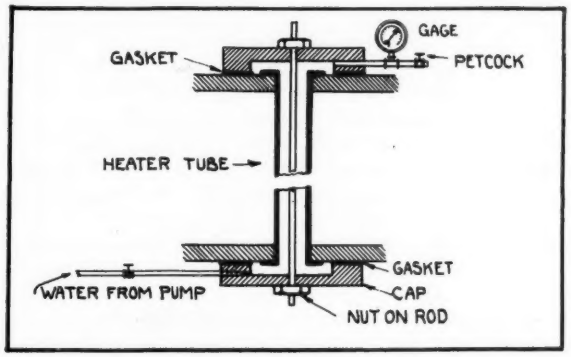


FIG. 4. ARRANGEMENT FOR TESTING HEATER TUBES

haust steam entering at high velocity with pulsating action. The tubes at the inlet bend back against the others, and vibrating, wear holes in the other tubes or break at the ends inside the tube sheet. The copper tubes are only about 3/64-in. thick, and are corrugated to give strength to withstand the internal pressure. Coiled heater tubes are not corrugated and, with a vacuum on the outside, seem to split altogether too easily. While running with a back pressure on the heater for exhaust steam heating, there is a pressure on the outside of the copper tubes which acts against the pressure of the water in the tube and prolongs the life of the heater tubes. In this case the exhaust steam from engines only passed through the heater (H) when the condenser was shut down for repairs. Ordinarily only the steam from the auxiliaries passed through the heater.

No doubt the position of the heater (H) saved No. 2 engine, with the aid of the 2-in. stop cock (b) which let the air into the engine exhaust line, also with the aid of the out-port valve (n^1), which prevented the condensate from the other exhaust main from being drawn back into the engine. Had the heater been placed between the engine and condenser, the condenser would have carried away as much of the water as the air pump could have handled, but the condenser would have been flooded and when the vacuum breaker (B) opened and choked with water, water would have been drawn into the low pressure cylinder the instant the throttle was closed.

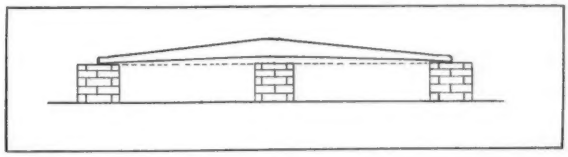
By a strange coincidence, this happened at shutting down time of the overtime run and no damage was done and little inconvenience experienced in the operation of the plant with the heater out of service as we run condensing during the day and exhausted through the heater at night.

From this accident I believe there should be two exhaust heads, and back pressure valves on every large heating installation where exhaust steam is used alternately for heating and condensing, or the exhaust pipe should be bypassed around the heater so it can be cut out of the exhaust line for repair when the tubes give out. This would allow of the heater being removed while making repairs, without reduction in service.

Cambridge, Mass. R. A. CULTRA.

Straightening Grate Bars

WE RECENTLY had some trouble with our grates and a few of the bars were warped out of shape. As we had no extra bars on hand to replace the deformed ones and as we did not have time to order new ones, we tried to straighten the old ones. They were placed upside down,



GRATE BARS PLACED ON PIERS TO BE HEATED

as shown in the accompanying sketch, and supported at each end by a brick pier. Another pier of the same height was placed under the center of the bar to prevent its sagging below the desired point when heated. A fire was then built under the bars and it was slowly heated. Weights were loaded on the top and the bars were gradually forced down until they rested on the central pier.

The job was completed satisfactorily and it didn't require much time.

Burlington, Iowa. TOM JONES.

Chasing Fine Threads on Steam Gage Glass Ring

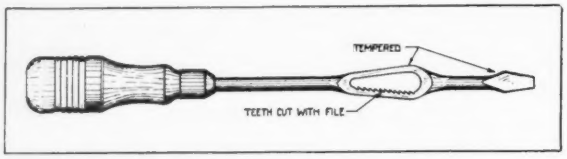
THREADS ON steam gage glass rings frequently become crossed, or if the ring is dented only a small amount, it is practically impossible to turn it back on the body of the gage without danger of ruining the thread entirely. Under the majority of circumstances, it is impractical or impossible to attempt to recut them with a tool in a machine. The sketch shows an improved method of cleaning and straightening the threads which is practical and easy to do, because a small tap can always be found where other tools are not available. Most of the rings carry a recess threaded to 20 threads per inch. Secure the tap in the vise with about ⅜ or ½ in. of it protruding from the side of the jaws. A broom handle is used to press the ring firmly but lightly against the tap. Slipping on the round broom handle, it can be turned against the tap and the threads trued up perfectly, cleaning them out thoroughly and taking out the slight dents which give so much trouble. The ring will have to be lifted as the tap runs in it. It is more easily done if someone can hold the handle or stick; it can, however, be supported by the body, though it makes the job a little more difficult. The writer has used this kink many times in roundhouses and plants where tools of almost any

kind were at a premium and crude, but instant inventions to meet the needs were the only salvation.

Missouri Valley, Ia. FRANK W. BENTLEY, JR.

Useful Modification of a Screwdriver

IN THE accompanying sketch is shown a simple modification of a screwdriver which one mechanic uses advantageously for several purposes. Teeth are cut with a file on the inside of a hole formed in the blade. This section is used for turning rods and cap screws, loosening small rusted parts such as bolts, etc. The same opening serves for the insertion of a turning bar for start-



SCREWDRIVER MODIFIED AS A GRIP WRENCH

ing tight screws, thus relieving the user from undue exertion.

This section of the driver is tempered so that the teeth will stand up under hard usage. This is a simple modification to incorporate in a screwdriver, but it extends the usefulness of the tool and makes it more conveniently handled.

Washington, D. C. G. A. LUERS.

Blowing Off Boilers

THERE ARE a great many ways of blowing off boilers. Generally the execution of this important duty is left to the fireman or the water-tender, who, having many other duties, regard it as a necessary evil of more or less trifling importance.

As a matter of fact, it is an exceedingly important part of the operation of a boiler plant and should be handled with considerable care and intelligence. The blowing off of the boilers has a great deal to do with the efficiency of the operation of the plant and should be given its due share of attention.

The amount of water blown off and the frequency with which it is blown off should be governed by the ever-changing conditions of water and load and should not be considered as a fixed program. Frequent tests should be made of the water in each boiler and the quantity blown off should be determined thereby. If the load is heavy, or the condenser return water salty, and the boiler water becomes dense, a greater quantity of blow-off should be made, or the blowing off should be done at more frequent intervals. If under these conditions an insufficient quantity is blown off, the boiler water will become more and more dense, consequently the fuel burned per unit of evaporation will be more. If too much water is blown off, there occurs a large loss of both water and the heat it contains.

The density of the water in the three drums of a Babcock and Wilcox boiler is by no means the same. Owing to the characteristics of each boiler, conditions of circulation, variation in temperatures throughout the path of the gases, etc., the tubes under the different drums evaporate the water at different rates.

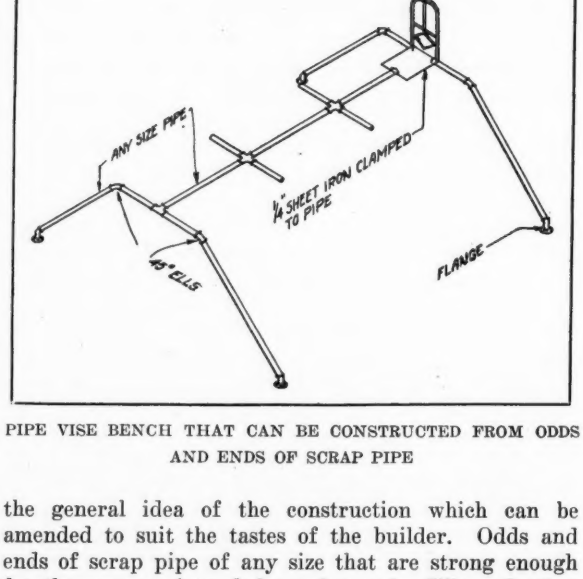
Some interesting experiments along this line were made by the writer and it was found that the density of the boiler water in the three drums varied as much as 300 parts of salt and solid matter per hundred thousand. Test cocks were installed in tube caps under each drum and tests made of the water. These tests showed that the density of the water ran 200 parts under the drum getting the first feed branch, 300 under the next and 500 parts per 100,000 under the drum getting the feed from the end branch.

A system was inaugurated whereby 8-hr. tests were made of the water in each drum and the blowoff divided among the three drums in accordance with these tests. A chart was drawn up showing the water tender just how much water to blow for a given density of water. Excellent results were obtained, which produced an increase in overall efficiency and the tube troubles were materially decreased.

Los Angeles, Calif. CLAUDE C. BROWN.

Handy Pipe Vise Bench

WHERE A great deal of hand pipe threading is to be done, especially in small sizes, the pipe bench here illustrated will be found to be sufficiently rigid, portable and easily and cheaply constructed. The sketch gives

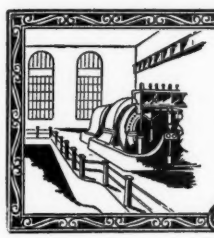


PIPE VISE BENCH THAT CAN BE CONSTRUCTED FROM ODDS AND ENDS OF SCRAP PIPE

the general idea of the construction which can be amended to suit the tastes of the builder. Odds and ends of scrap pipe of any size that are strong enough for the purpose intended can be used. Ells and other fittings can be used that are unsuitable for any other purpose.

Berkeley, Cal. JACK L. BALL.

THE AUGUST PRODUCTION of gas and fuel oils was 1,010,657,879 gal., a decrease of 42,000,000 gal. from the July output, but an increase of 66,000,000 gal. over the production for August, 1922. Stocks of these oils Sept. 1 were 1,462,182,129 gal., an increase of 61,000,000 gal. over Aug. 1, and an increase of 95,000,000 gal. over Sept. 1, 1922. Exports of these oils for August amounted to 127,000,000 gal., an increase of 6,500,000 gal. over July, and of 68,000,000 gal. over August of last year. Consumption of gas and fuel oils in August was 833,000,000 gal., a decrease of 69,000,000 gal. from July and of 44,000,000 from August, 1922.



PROBLEMS IN OPERATING POWER EQUIPMENT

Utilization of Exhaust Steam

WE HAVE been having some difficulties with a part of the heating system at our plant and I would like to have the opinion of Power Plant Engineering as to how the situation may be bettered. The plant has 450-hp. boiler capacity, and open feed water heater and a 150-hp. non-condensing Corliss engine, exhausting to atmosphere during the summer months.

Last winter, we tried to use the engine exhaust to heat a new office space located at the far end of the building about 250 ft. from the engine room. The engine room floor is about 3 ft. higher than the basement of the office. With a vacuum pump located in the engine room pulling about 15 in. vacuum, we found it impossible to use exhaust steam for heating, owing to the fact that we could not return the condensate. What should be done to this system to make it function properly? Will it be necessary to install receivers and traps? Must the vacuum pump be placed at the lowest point of the system? Can the returns from this system be made to discharge into the feed water heater?

We have four drying rooms about 20 by 20 ft., located directly over the engine room, which are now heated with live steam. The condensate is returned through traps to the feed water heater. In summer, instead of wasting the exhaust steam from the engine I suggested using it to heat the drying rooms. How should the system be piped for this purpose, using the same coils so that either live or exhaust steam could be used as the occasion demands? Can the same return line and traps be used with either method of heating?

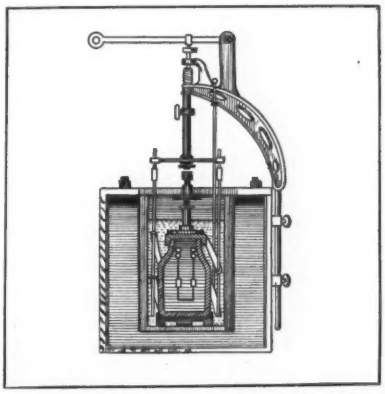
We get sufficient return steam from the plant to keep the feed water at the right temperature without using the exhaust from the engine which ordinarily operates under a back pressure of 10 lb. gage. E. W. M.

Water Equivalent of a Calorimeter

IN SPEAKING of a proximate coal analysis, what is meant by the term, "Water equivalent of the calorimeter," and how is it determined? W. S. M.

A. When a sample of fuel is burned in a calorimeter the heat liberated is absorbed by the water in the calorimeter and the parts of the apparatus itself. The resulting rise in temperature of both the water and the parts is a measure of the heat liberated. Mathematically this heat is equal to the sum of the products of the mass times the specific heat times the rise in temperature of all the elements absorbing heat. To simplify the computations, the specific heat and mass of all the parts except the water are found and the sum of the products of these two items taken. This figure represents the weight of water that would be required to absorb the same quantity of heat as the parts of the calorimeter in passing through the same range of temperature, and is the water equivalent of the calorimeter. In practice this weight is added to that of the water actually used and the calculations are based on that figure.

This equivalent may be found in any one of several ways: by calculation, by the method of mixtures, and by trial with a known amount of heat. To calculate the equivalent, weigh separately each part of the apparatus that goes through the same temperature range as the



SECTION THROUGH MOHLER BOMB COLORIMETER SHOWING PARTS WHICH UNDERGO THE SAME TEMPERATURE CHANGE AS THE COLORIMETER WATER

water. Multiply each weight by the specific heat of the material of which the part is made. The sum of these products is the desired equivalent. An allowance should be made for the poor conductivity of glass or wood which has the effect of making only a surface layer of the material subject to the change in temperature. Allowance should also be made for parts that project above the surface of the water.

To determine the equivalent by the method of mixtures, partly fill the calorimeter vessel with a known weight of water, allow all parts to come to thermal equilibrium, then determine the temperature and the rate of radiation. Add a known quantity of water of either a higher or lower temperature to fill the vessel completely. Stir the water until thermal equilibrium has been established again, then read the temperature and determine the final radiation rate. When the correction for radiation has been made, the discrepancy in the heat balance is the heat absorbed by the parts of the calorimeter and is the product of the water equivalent and the temperature range.

The water equivalent may be found by trial by making a run as with an unknown fuel excepting that heat is supplied by means of an electrical resistance heater inside the bomb. The electrical input is accurately measured with a wattmeter and the heat supplied can be found. Calculations are worked backward to find the water equivalent.

Ordinarily the water equivalent is determined only once, but strictly the value thus found is not strictly accurate unless the same temperature range results in a test that was used to make the determination. This is true because the specific heat varies somewhat with the temperature.

Power Required for Air Compressor

WE HAVE in our plant a two-stage air compressor direct connected to a compound steam engine. The compressor is 17 by 28 by 24 in., and the engine is 20 by 30 by 24 in. Steam pressure is 105 lb. and the air pressure 90 lb. gage. Exhaust back pressure is 5 lb. gage. What should be the pressure in the receiver and in the inter-cooler? What should be the cutoff in the high pressure steam cylinder? What should the temperature rise of the air be?

W. G. H.

A. For two-stage compression with intercooling, the intermediate pressure for the least expenditure of energy should be equal to the square root of the product of the initial and the final pressures, i.e.

$$p_2 = \sqrt{p_3 \times p_1}$$

When this condition obtains, the work required to compress a given quantity of air through the two stages is given by the equation

$$W = n \div (n - 1) \times p_1 v_1 \{2(p_3 \div p_1)^{(n-1) \div 2n} - 2\}$$

If we consider that the compression is adiabatic, n is equal to the ratio of the specific heat at constant volume to that at constant pressure or 1.4. With a 28-in. low pressure cylinder, the volume displaced per stroke in that cylinder will be $v_1 = 0.7854 \times 28^2 \times 24 \div 1728 = 8.55$ cu. ft. If the initial pressure is 14.7 lb. per sq. in. absolute and the final pressure 90 lb. gage or 104.7 lb. absolute, then we may substitute the known quantities in the equation as follows:

$$W = (1.4 \div .4)\ 144 \times 14.7 \times 8.55 \times \{2(104.7 \div 14.7)^{.4 \div 2.8} - 2\}$$

$$= 63{,}400\ (2 \times 7.12^{.143} - 2)$$

$$= 63{,}400\ (2 \times 1.325 - 2)$$

$$= 63{,}400 \times 0.65 = 41{,}200 \text{ ft.-lb. per stroke or } 82{,}400 \text{ ft.-lb. per revolution.}$$

Assuming 100 per cent overall mechanical efficiency, we see that the work done by the driving engine would have to be 82,400 ft.-lb. per revolution. If the engine is properly designed and is operating with the correct receiver pressure, the work should be equally divided between the high and low pressure cylinders. It should also be equally divided between both ends of either cylinder so that the work done per stroke per cylinder will be ¼ of 82,400 or 20,600 ft.-lb.

The work done per stroke per cylinder equals PLA where P is the mean effective pressure in say the high pressure cylinder, L, the length of stroke in feet, and A the area of the piston in square inches. Solving then for P, we have $P = 20{,}600 \div (2 \times 0.7854 \times 20^2) = 32.7$ lb. per sq. in. With the engine dimensions given, the receiver pressure should be equal to $P_1 \div R$ (the cylinder ratio, which is equal to $30^2 \div 20^2 = 2.25$). From this it is seen that the receiver pressure $P_2 = 119.7 \div 2.25 = 53.4$ lb. per sq. in. absolute or 38.7 lb. gage.

With this back pressure on the high pressure cylinder, if we are to have a mean effective pressure of 32.7 lb., the mean forward pressure must be $53.4 + 32.7 = 86.1$ lb. per sq. in. If we assume that the expansion of steam in the cylinder gives a perfect hyperbolic curve, then the ratio of the mean forward pressure to the initial pressure, which in this case will be $86.1 \div 119.7$, is 0.715, then according to Mariotte's law, the cutoff required would be at about 35 per cent of the stroke.

Allowing 80 per cent overall mechanical efficiency, the necessary mean effective pressure in the high pressure cylinder would be $32.7 \div 0.80 = 41$ lb. per sq. in. The mean forward pressure would then be $41 + 53.4 = 94.4$ lb. and the ratio of the mean forward to the initial pressure, $94.4 \div 119.7 = 0.785$. Again from Mariottes' law, as presented in table form in Kent's handbook, it is found that the necessary cutoff would have to be at about 42 per cent of the stroke.

The final absolute temperature of the air after compression in the second stage after perfect intercooling is assumed may be found from the equation $p_1 v_1 \div T_1 = p_2 v_2 \div T_2$ i.e. $T_2 = p_2 v_2 \div p_1 v_1 \times T_1$. In order to solve this equation, it is necessary to know the initial and final volumes, v_1 and v_2. Assuming unity initial volume v_1 then if it is considered that the compression is adiabatic, as before, v_2 may be found from the expression $p_1 v_1^n = p_2 v_2^n$. Solving for v_2^n we have $v_2^n = p_1 \div p_2 \times v_1^{1.4} = 14.7 \div 104.7 \times 1^{1.4}$. Then $v_2^{1.4} = 0.14$ and $v_2 = 0.25$ cu. ft. Going back to the former equation, $T_1 = 104.7 \times 0.25 \div 14.7 \times 1 \times (460 + 70) = 994$ deg. absolute. Subtracting 460 deg. from this quantity, the final temperature will be 484 deg. F.

Compound vs. Simple Engines

WILL YOU kindly explain to me what are the relative advantages and disadvantages of a compound steam engine as compared with a simple engine? I have inquired of a number of engineers in this locality, but I seem to be unable to get an answer that will satisfy the examiners of the local board. A. E. M.

A. When high-pressure steam expands in a single-cylinder engine of the ordinary double-flow type down to a comparatively low point, a portion is condensed on the metal surfaces. At the end of the stroke and during exhaust, some of the water is re-evaporated, but the steam so formed is exhausted without doing work. If the same weight of steam is expanded through the same pressure range in two cylinders, the temperature range in each cylinder will be less, initial condensation will be reduced and part of the heat lost in the first cylinder will do work in the second. The higher the temperature range, the more pronounced will be the thermal economy effected by compounding. Because of the first cost, complexity, cost of lubrication, attendance and maintenance, the number of stages is limited commercially.

The principal object of compounding is to permit the advantageous use of high pressures and large ratios of expansion and for this reason this type of engine is usually not considered for pressures lower than 125 lb. per sq. in. gage. The thermal gain for the lower pressures is usually more than offset by fixed charges and other practical considerations. In general, compounding increases the steam economy at rated load from 10 to 25 per cent for non-condensing engines and from 15 to 40 per cent for the condensing engines.

The relative advantages and disadvantages of the compound engine as compared with the simple engine may be briefly summarized as follows:

Advantages	Disadvantages
1. High ratio of expansion.	1. Higher first cost due to multiplication of parts.
2. Less cylinder condensation.	2. Greater bulk.
3. Less clearance and leakage losses.	3. Increased complexity.
4. Equal crank effort.	4. Greater wear and tear.
5. Greater economy in steam consumption.	5. Increased radiation loss.

Combustion Problems

If a coal analysis shows

Moisture .....12 per cent
Ash .....11 per cent
Combustible .....77 per cent

and the actual evaporation is 6 lb. of water per pound of coal, as fired, what is the evaporation per pound of dry coal and per pound of combustible? What is the equivalent evaporation from and at 212 deg. F., per pound of combustible, the steam pressure being 128 lb. absolute and the temperature 156 deg. F.?

A. Under these conditions, the evaporation per pound of dry coal will be 6 divided by the sum of the percentages of ash and combustible = $6 \div 0.88 = 6.82$ lb. In like manner, the evaporation per pound of combustible is $6 \div 0.77 = 7.8$ lb. As the total heat of steam at 128 lb. abs. is 1190.7 B.t.u., the equivalent evaporation, based on combustible, is:

$$(1190.7 - 156 + 32) \div 970.4 \times 7.8 = 8.58 \text{ lb.}$$

2. If a certain coal cost $6 per T. and has an analysis of:

Moisture .....11 per cent
Ash ..... 9 per cent
Combustible .....80 per cent
B.t.u. per lb., dry.....13,050

how many B.t.u. are available for one cent? If the contract calls for 48,000 B.t.u. for one cent, what should be the price per ton? If the cost of ash removed is $0.75 per T., what allowance might be made in the price of the coal?

A. If this coal has a heating value of 13,050 B.t.u. per lb., dry, then the heating value, as fired, will be

$$13{,}050\ (0.80 + 0.09) = 11{,}600 \text{ B.t.u. per lb.}$$

As the cost is $6 per T., or 0.3c per lb., this obviously is the cost of 11,600 B.t.u. and the heating value that may be bought for one cent is $11{,}600 \div 0.3 = 38{,}700$ B.t.u. If the contract calls for 48,000 B.t.u. for one cent, then the price per ton would have to be $38{,}700 \div 48{,}000 \times \$6 = \$4.84$.

The weight of ash in a ton of coal is $2000 \times 0.09 = 180$ lb. Then if a credit is to be allowed of $0.75 per T. of ash, or 0.0375c per lb., the allowance per ton of coal would be $0.0375 \times 180 = 6.75$c. The net price of the coal would then be $\$4.85 - \$0.07 = \$4.78$ per T.

3. The temperature in the boiler room is 70 deg. F., the coal burned contains 3 per cent hydrogen, and the temperature of the flue gases in the uptake is 575 deg. F. What is the heat loss due to moisture resulting from the combustion of the hydrogen?

A. Loss due to hydrogen in the fuel may be mathematically expressed as

$$h = 9H\ (1090.6 - t + 0.46t_c)$$

Where H is the weight of hydrogen per pound of fuel, t is the temperature of the fuel entering the furnace, and t_c is the temperature of the chimney gases. Substituting the known values in this equation, we have, $h = 9 \times 0.03\ (1090.6 - 70 + 0.46 \times 575) = 0.27 \times 1284.6 = 347$ B.t.u. per lb. of coal as fired.

Thickness of Boiler Tubes

I would appreciate it if you will supply me with data on the thickness of boiler tubes required for various sizes to withstand various pressures; this for charcoal iron, lapwelded steel and seamless steel tubes.

G. S. S.

A. For a given diameter of tube and allowable working pressure, the thickness required will vary greatly according to whether the pressure is applied on the inside or outside of the tube. The dimensions as given by the American Society of Mechanical Engineers boiler code committee in its report on the construction of steam boilers are as follows:

The minimum thickness of tubes used in fire tube boilers for maximum allowable working pressures not to exceed 175 lb. per sq. in. shall be for

Diameters from 1 in. to 2½ in.....No. 13 B.W.G.
Diameters from 2½ in. to 3¼ in.....No. 12 B.W.G.
Diameters from 3¼ in. to 4 in.....No. 11 B.W.G.
Diameters from 4 in. to 5 in.....No. 10 B.W.G.
Diameters of 5 in.....No. 9 B.W.G.

For each increase of one gage in thickness above that shown in the table, the maximum allowable working pressure may be increased by an amount equal to 200 divided by the tube diameter in inches.

For water tube boilers, the maximum allowable working pressure may be found from the equation

$$P = (t - 0.039) \div D \times 18{,}000 - 250$$

where P is the maximum allowable working pressure in pounds per square inch, t is the thickness of the tube wall in inches, and D, the outside diameter of the tube in inches. To find the tube thickness required for any desired tube diameter and pressure this equation may be transposed to the form

$$t = (P + 250) \times D \div 18{,}000 + 0.039$$

These figures allow a maximum fiber stress of 16,000 lb. per sq. in. and are applicable to charcoal iron, lapwelded steel and seamless steel tubes.

Covering Ammonia Line in Service

It is our intention to cover the suction lines in one of our cold storage houses. At the time this building was erected, the uncovered suction lines were placed inside the cold storage rooms which are all direct expansion. This leaves the temperature in some of our rooms beyond control and we find that it is almost impossible for us to cut off refrigeration on this house in order to defrost and thoroughly dry these lines so that they can be insulated. What means can be employed to enable us to cover these lines?

F. B. O.

The formation of heavy scale in the tubes of a boiler is fully as serious an economic crime as it would be to force the operators to wear double thickness overcoats.

POWER PLANT ENGINEERING

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Recovery of Combustible Matter from Refuse

One of the factors of outstanding importance in modern power plant operation is the attainment of high fuel economy, that is, the securing of the most effective release of the total amount of energy in the fuel. Much has been accomplished in this direction, and the efficiencies obtained today are considerably higher than they were ten years ago.

This advance in the more effective use of fuel, however, has been brought about mostly by advances in furnace design and combustion control. Little has been done in the matter of recovering combustible material from the ash and clinker.

There are a number of different systems in use for effecting this removal, and in an article appearing in the pages of this issue C. H. S. Tupholme of London describes some of them. These methods, which are all European developments, may not be applicable in this country because of different economic conditions, but it is believed that with certain modifications they could be made economically possible. At any rate, the subject is one which may well be given thorough consideration, from the standpoint of fuel conservation.

Electrical Protective Equipment

Because of the increasing dependence that is being placed upon the operation of electrical systems, it is becoming more and more important to provide protective equipment that will insure uninterrupted service at all times. This applies not only to the vast electrical networks of our public utility systems, but to the privately owned plant, as well.

Twenty years ago, when the electrical industry was in its infancy, we looked upon an interruption in our electric power or light supply as a necessary evil. When the lights went out, we made use of the gas jets which were usually an integral part of the electric light fixture—they were put there for just such emergencies.

But today there exists a different order of things. When the electric service fails, we are no longer content to light the gas, or to stand around and calmly await the resumption of the power supply. Gas jets are no longer provided. Today we expect uninterrupted service—we demand it in fact, and when on rare occasions something does happen and we are without light or power for a brief interval, we lose our calm demeanor and deprecate the character of the service in vigorous language. Clouds may obscure the sun, but the electric lamp must shine forever.

It is natural, because of this insistent demand for continuous service, that considerable attention has been directed lately towards the development of adequate protective equipment for electrical apparatus. Every vulnerable point in the entire electrical system must be guarded against damaging influences, both internal and external, and to that end a multitude of protective measures have been devised.

For the purpose of acquainting the readers with modern protective methods, Victor H. Todd has prepared a number of articles on this subject, the first of which appears in this issue. The practical manner in which Mr. Todd has handled this subject should appeal to the engineer in the plant, and for this reason we direct them to his attention.

Boiler and Furnace Number

SPECIALIZED ISSUE FOR JAN. 1, 1924

PROGRESS IN BOILER design, construction and operation has advanced so rapidly during the last few years that it seems essential to summarize the recent changes and the practice which is recognized and adopted as being most conducive to economical results. This involves not only the boiler structure, but the arrangements for burning the fuel and for transferring the heat from the hot gases to the contents of the boiler. Hence the setting, the furnace, the grates and the draft control must be considered in dealing with the subject of economical boiler plant practice.

TYPES OF BOILERS

Different types of boilers vary so greatly in details and in adaptability for various fuels and uses that separate consideration is required for each. The classification divides into: Horizontal Tubular, Vertical Tubular, Locomotive, Scotch Marine, and Water Tube of various kinds such as inclined and bent tube with horizontal and vertical arrangement of each.

STRENGTH

Under this head comes the discussion of materials, sizes and, best arrangement to give the ability to resist steam pressures of ever increasing intensity; covering, in general, shells, joints, heads and stays. As these are common to all boilers, they will be treated in a single section, and the special adaptation of the principles to each type of boiler taken up in treating that type.

DETAILS OF TYPES

For Horizontal Return Tubular boilers, aside from strength, the important factors in securing economy are size, number and arrangement of tubes, feed inlet and steam delivery, setting and suspension, and proportions and arrangement of furnace and combustion space. Careful study of modern practice in regard to these features will be made in this section.

For Vertical Tubular boilers, the factors to be considered are largely the same as for the horizontal, but with special features such as the water leg and feed supply. These, as well as special designs, will be fully covered.

Locomotive type boilers are used mostly in portable plants. The points which call for special treatment are the firebox, staying, feed inlet and steam delivery.

Internal-furnace horizontal boilers, typified by the Scotch marine design are adapatable for many stationary plants. The furnaces, flues, rear end arrangement and covering are the special features to be discussed.

Water-Tube boilers are the ones most commonly used in the larger plants. They vary so greatly in arrangement and detail that it will be necessary to treat them at considerable length; details of drums, headers, baffling, superheating will be included, also special features of different makes.

FURNACES

Necessary to proper functioning are correct proportions and construction of grates, fire box, baffles and arches, combustion chamber, and uptake. Adaptation of grate and furnace to the fuel; air supply, mixture and flame travel; contact of gases and cleanliness of heating surfaces; shape and area of gas passages; these are some of the vital factors in economy about which it is essential for the power plant engineer to have information on the latest and best practice.

STOKERS

Types and their best usefulness, details of construction and operation, methods of control of feed and air supply, provision for removal of ashes and clinkers, all are of vital interest to the man in charge of a plant, with demand for big capacity and intensive use of installation, new problems have arisen. How are they being solved? This question will be given full answer.

SPECIAL FURNACES

For fuels such as oil, gas, pulverized coal and wood and other refuse furnaces are needed which are adapted to the character of the fuel. The arrangement of brickwork, baffles and gas passages must be changed; burners and piping must be provided, special storage arrangements for the fuel are necessary. What has experience shown to be the best devices and methods for insuring satisfactory and continuous operation?

Practice varies according to conditions, so that it will be necessary to give the requirements for burning each fuel successfully, then to show how these requirements are being met.

BOILER EQUIPMENT

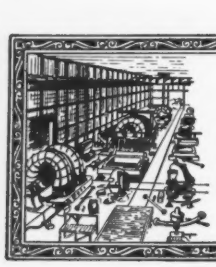
On every boiler there are needed certain safety devices, valves and fusible plugs; also means for controlling inlet of water and outlet of impure water and of steam. This equipment will be given the attention which its importance requires to insure safe and dependable boiler service.

Water must be supplied and at intervals, blown down; steam must be delivered; safety valve discharge should be carried away; and moisture should be kept out of the steam mains. All this requires piping. On its correct proportioning and arrangement depends, to a large extent, convenience and flexibility in plant operation. Hence careful attention will be given to this feature of boiler plant design and installation.

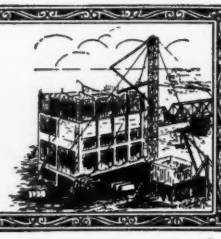
OPERATION

With a plant properly designed, provided with best modern equipment and correctly installed, it would seem that results might be certain. But there is always the element of care in operation, which must be exercised if the maximum results are to be obtained. The right methods for routine and periodic inspection and tests must be found by each plant manager for his own plant. But they should be worked out with a full knowledge of correct principles and the practice which has been found best in other plants.

To supply this knowledge will be the purpose of this section and of the issue as a whole.



POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



Another Plant Added in $375,000,000 Project

SOUTHERN CALIFORNIA EDISON CO. PLACES 105,000-HP. PLANT IN SERVICE AS PART OF BIG CREEK-SAN JOAQUIN PROGRAM

ON OCT. 11, the Southern California Edison Co. placed a 105,000-hp. hydroelectric plant in operation, which forms one more link in the $375,000,000 development program for the Big Creek-San Joaquin watershed. The entire project, when completed, will produce some 1,400,000 hp. and will be marked by the solving of numerous engineering problems, one of which is the Florence Lake tunnel. Nearly a mile high in elevation above the site of the new plant, Edison construction men are now working on this 21-ft. tunnel, which will be 14 mi. in length and which will tap the enormous watersheds which lie beyond one of the main ranges of the High Sierras.

This tunnel will be more than twice as long as the Rogers Pass tunnel on the Canadian Pacific Railway which at present is the longest tunnel on the American continent, and it will be more than a mile longer than the Simplon tunnel through the Alps in Switzerland, which, pending the completion of the Florence Lake tunnel, is the longest in the world.

Power house No. 3, as the new plant is known, is equipped with three 35,000-hp. generating units of the latest type. These are propelled by diversion of the waters of the San Joaquin River through a tunnel 6 mi. in length which has its upper portal at a new dam which the company has thrown across the main stream. Three pressure mains drop the water on the generating machinery at a fall of 760 ft.

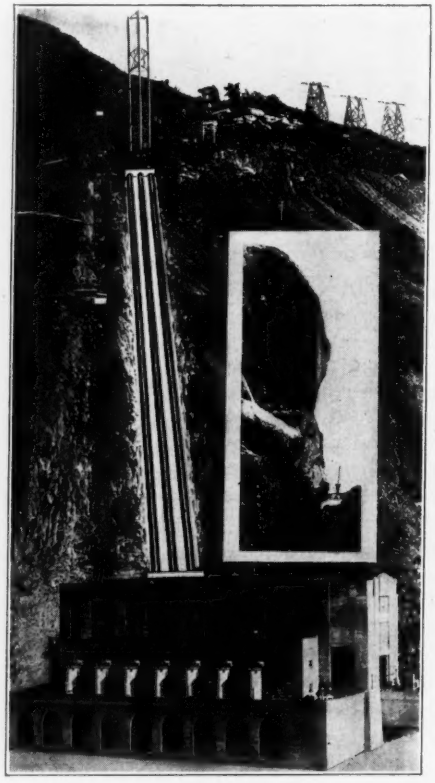


FIG. 1. THREE 35,000-HP. UNITS OPERATE UNDER A 760-FT. HEAD. SMALLER VIEW SHOWS LOCATION OF PLANT IN CANYON

Steel and concrete construction was used for the building, which is 200 ft. in length, 135 ft. wide and 110 ft. high from the tailrace floor to the roof which is of reinforced concrete and structural steel. Excavation for this building, which was carried on by means of hydraulic sluices and steam shovels, was started on June 15, 1922, and the first concrete was poured in the foundations on Jan. 10, 1923. The power house structure contains the generators, but the switching station is of the outdoor type and becomes a part of the first installation of 220,000 v. ever to be placed in actual operation. The generating room of the power house is 55 ft. in width and 70 ft. high.

There are many novel features of this plant, one of which is the omission of a separate lubricating oil system. In this installation, each bearing of the main unit has its own lubricating oil pump, thus eliminating all outside oil filters, pumps, supply tanks and piping, which are liable to cause more or less trouble in operation.

Another novel feature of the design is the elimination of the basement in the generator room. As the plant is laid out, the operating floor is on two levels, one at the base of the generator, and the other at the elevation of the turbine, so that practically all the equipment is in view of the operator at all times.

The switching station is 195 ft. in width by 430 ft. in length, and consists of a series of concrete benches excavated on the slope of the mountain, with a difference in elevation of 46 ft. between the upper and lower benches. These benches support the oil switches, disconnecting switches, frames and insulated piers for carrying the bus structure.

Penstocks for the turbines are made entirely of lap welded pipe, varying in diameter from 7½ ft. to 6 ft., the penstock valves at the bottom of these lines being the needle type valve. At the upper end of the penstocks are installed 7½-ft. diameter butterfly valves, arranged for control from the power house.

At the upper end of the penstocks is installed a manifold of special design, which connects the six penstocks of the ultimate installation with an 18-ft. steel pipe, connecting to the tunnel. At this location there is also

installed a surge tank excavated from the solid rock. It consists of a chamber in the shape of a huge hour-glass, hewn out of the solid granite of the mountain and connected to the tunnel at a point near its outlet end.

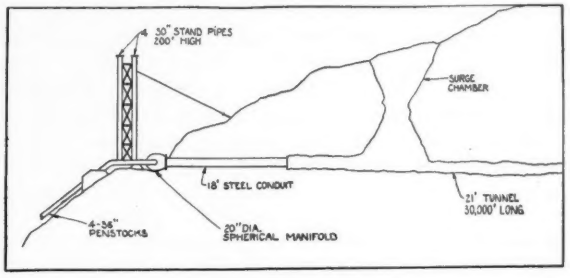


FIG. 2. SURGE CHAMBER IN SOLID ROCK A FEATURE OF THE DEVELOPMENT

This large chamber is 75 ft. in diameter at its base, narrowing to a diameter of 25 ft. at its center or neck, and increasing again to a diameter of 75 ft. at the top or surface. It is 200 ft. in height and is so located that its top or mouth, which opens through the mountain, is at a slightly higher elevation than the elevation of the tunnel inlet at the lake end.

The purpose of this hour-glass surge chamber is, of course, to take care of the surges that may be caused by the variation of load and water demand from the tunnel. It will be appreciated that the surge consequent to any great variation in water demand, either increasing or decreasing, will be enormous due to the great body of water which is in motion in the tunnel, 21 ft. in diameter and 6 mi. long.

At power house No. 3 are intalled, in addition to the above described hour-glass surge chamber, four 30-in. stand pipes, some 200 ft. high, as an additional opportunity for the dissipation of the energy of surges. These four stand pipes are tied together by fabricated steel members so that the four stand as a single tower, each stand pipe being, however, connected to an individual penstock.

The method used in tying the penstocks into the tunnel is interesting. As before mentioned, the tunnel is a 21-ft. cut through the solid granite and is unlined except for several hundred feet where soft strata of wet sand were encountered, in which cases it was cribbed and concreted. At the delivery end of the tunnel, an 18-ft. riveted steel circular pipe or conduit was carried some 300 ft. back into the tunnel and a heavy anchor flange installed in sections. This steel conduit was then securely concreted in place. At the delivery end of this steel conduit where it merged from the mountain was installed an extra heavy steel spherical chamber, 20 ft. in diameter, heavily riveted and reinforced, and circled with two diametral built-up steel rings which encircle the entire shell on two opposite diameters.

The intake to the tunnel consists of a reinforced concrete structure, 115 ft. in height. The flow of the water into the tunnel is regulated by a 22-ft. diameter circular sluice gate, which was designed by the Edison Company's engineering department. The diversion dam is a simple arch type concrete structure.

At the junction of Big Creek and the San Joaquin River are the dam and tunnel intake and the power house is approximately 6 mi. down stream at the junction of Mill Creek and the San Joaquin River. Three generating stations carrying the waters from Huntington Lake, at an elevation of 7000 ft. to the intake of this plant at 2230 ft. elevation are already in operation above this plant on the Big Creek drainage.

There will be an additional plant constructed directly below the No. 3, utilizing all the remaining available head in the Grand Canyon of the San Joaquin River.

Gorgas Plant Sale Causes Controversy

EVEN though the Gorgas steam power unit of the Muscle Shoals, Ala., properties of the Government has been sold to the Alabama Power Co., the final disposition of the plant has aroused considerable controversy. Secretary of War Weeks' action in this sale has resulted with a published statement of Henry Ford, bitterly arraigning Secretary Weeks for preventing action on the Ford Motor Co.'s offer to buy and lease the properties.

It is stated that Secretary Weeks, on Oct. 12, carried the published statement of Mr. Ford into the Cabinet meeting, considering it grave enough to take up directly with the President.

Mr. Coolidge is known to be thoroughly in accord with the action taken by the War Department in selling the Gorgas plant to the Alabama Power Co., and the position of the President, as stated at the White House, is that the Ford offer is still before Congress, has not been affected by the sale of the Gorgas project and that Mr. Ford be given every opportunity to buy and lease the Muscle Shoals properties.

Mr. Coolidge, it is stated, after the recent sale of the Gorgas unit, told visitors that the Government did not consider the plant as essential to the purposes which Mr. Ford had stated that he had in view in acquiring Muscle Shoals.

Administration officials, it is stated, including the President, have asserted that Mr. Ford could build an auxiliary steam plant for less than the amount represented in the Gorgas plant sale, which sum it is announced would be credited to Mr. Ford on his bid for the entire property. The view of the administration is that the Ford offer is still before Congress, and that body must determine the matter.

PROMINENT cotton manufacturers of Maine and Massachusetts made a careful inspection of the plant of the Union Water Power Co., controlling the Androscoggin River at Lewiston, Me., and then further inspected the river towards its source. The inspection was made with a view of ascertaining the available water supply.

Negotiations are already under way for the development of additional power through co-operation of the Union company at Lewiston and the Central Maine Power Co. and the linking up of their transmission lines in the general plan to provide the state with continuous power should local interruptions to plants take place.

Representatives of the Continental, Androscoggin, Bates, and Bleachery & Dye Works of Maine and representatives of the Lockwood, Greene & Co. and other manufacturing interests of Massachusetts were in the party.

House Turbine Operates Only in Emergencies

IN STATIONS where motor driven auxiliaries are employed and stage bleeding of the main generating unit is arranged for feed water heating, a reliable source of power for the auxiliary bus line is the main consideration. The system that offers the best economy with no sacrifice of reliability is the one to be desired.

Connection of the auxiliary bus directly to the main bus through a transformer, would be the most economical arrangement, but reliability or assurance of continuity of service is lacking since disturbances on the main line would be communicated to the auxiliary bus and would affect the operation of the auxiliaries.

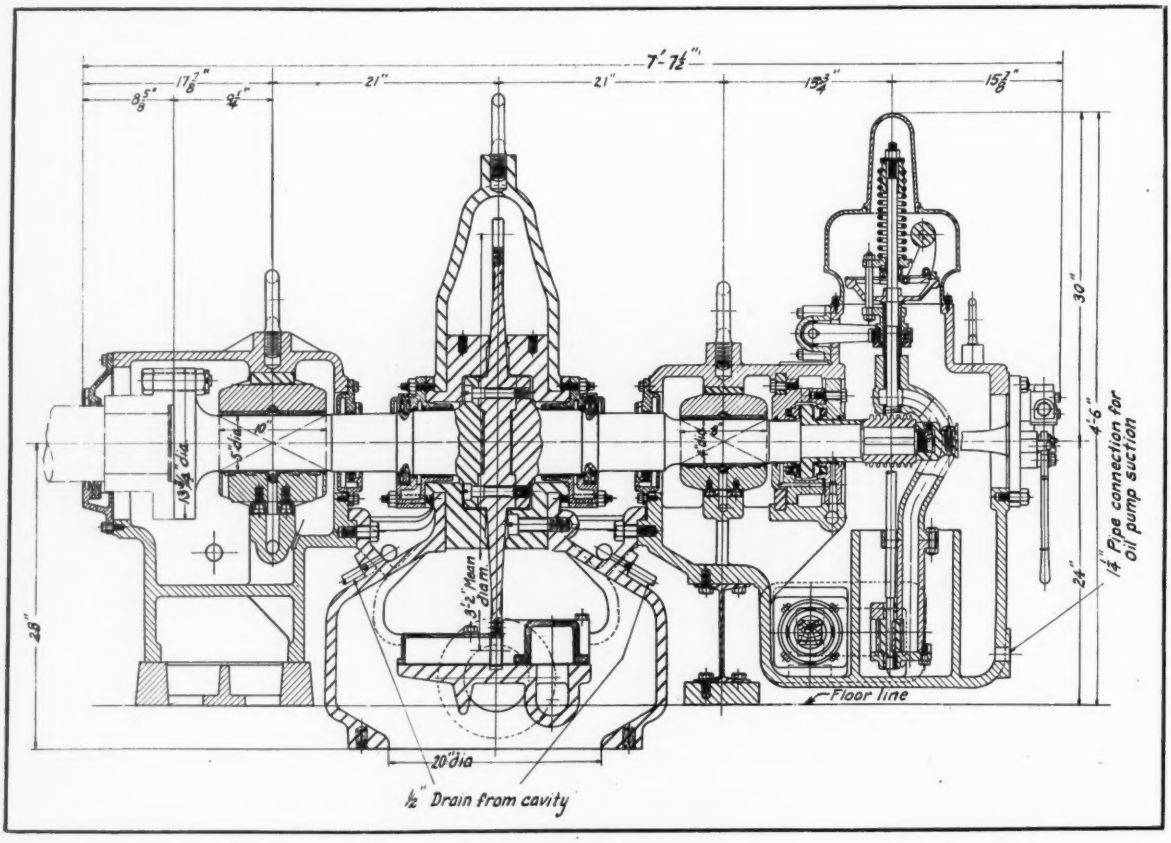
If the auxiliary bus is energized by an auxiliary generator coupled to the shaft of the main unit, the economy will be good, due to the low water rate of the large unit, and the auxiliary bus will be electrically isolated from the main bus. With this arrangement, the motor drives will be unaffected by disturbances on the main line; but a stoppage of the main unit will leave the auxiliaries without power unless another reliable source is available.

To use power generated by the main unit for driving the auxiliaries and at the same time avoid electrical connection between the busses with its attendant possibilities for damage to the auxiliary motors through electrical surges originating on the main line, connection between the main and auxiliary busses may be made through a motor generator set, the motor being driven by current through a transformer from the main bus, and the generator supplying current to the auxiliaries. The auxiliary bus will not be influenced by disturbances on the main line with this arrangement, but the auxiliaries are still dependent upon the operation of the main unit.

If a steam turbine is coupled to the motor generator set, it will be possible to provide power for the auxiliaries independent of the operation of the main unit. For this service the Westinghouse Electric & Manufacturing Co. has recently developed a turbine, a sectional assembly of which is shown in the accompanying illustration. It is designed with a view toward simplicity and reliability rather than for steam economy. Coupled directly to the motor generator above mentioned, this turbine will normally be run idle, using no steam. There will be a small pipe connection between its casing and the main condenser, to maintain a vacuum within the casing, thereby reducing windage loss and heating effect of the revolving blades.

This is an impulse type machine having a single row of blades with primary nozzles and reversing chambers by means of which the steam is passed and repassed through the revolving blades. The casing is of steel casting to withstand steam at high pressure and temperature.

With a unit intended only for emergency service, the question of economy is of little importance and for this



IMPULSE TYPE TURBINE WITH SINGLE ROW OF BLADES IS DESIGNED FOR EMERGENCY OPERATION OF STATION AUXILIARIES

machine it is intended that the exhaust will be discharged to the atmosphere during its emergency operation as a turbine. On account of the high vacuum to be regularly maintained in the turbine casing, the shaft sealing glands must be effective and the exhaust must be closed by a water sealed relief valve which will automatically open when required to exhaust steam, but at other times will remain effectively closed against air leakage.

The governor is of the flyball type, similar to that used on large turbines and controls the steam admission valve through an oil relay, insuring positive valve action. The regular speed of this emergency turbine for use with 60-cycle installations is 3600 r.p.m., and this speed will be normally maintained under operating conditions by the synchronous motor forming part of this unit. When so operating, the steam admission valve will remain closed. Should the frequency of the main current be lowered from any cause, the speed of the emergency turbine will be accordingly lowered and its governor will come into action, admitting steam to the turbine and thereby maintaining the auxiliaries in operation. The oil relay operated by the governor will open the admission valve to its fullest extent while the speed of this unit is below normal.

Lubrication of the bearings is effected by an oil circulating system consisting of a reservoir, oil cooler, oil pumps, pressure regulator, and the connecting piping. The main oil pump is of the rotary gear type, driven by gears from the turbine shaft. There is provided also a steam driven auxiliary oil pump used to start circulation in the oiling system when starting up. The shaft sealing glands are of the combined labyrinth steam sealed type. The steam seals may be used when starting the unit under vacuum, before the machine reaches a speed at which the water seals become effective. End thrust of the spindle is absorbed by a Kingsbury bearing.

Shaft connection between the turbine and generator is made through a solid flanged coupling and there is only one generator bearing. Connection between the generator and motor shafts is made through a flexible coupling; there are two motor bearings as usual.

Steam is supplied through a throttle valve having a tripping device through which the steam may be instantly cut off either by hand or automatically by the emergency stop governor which may be set to operate at a predetermined speed.

As indicated in the accompanying illustration, the turbine casing supports are located close to its centerline and will be little affected by expansion due to changes in temperature. The governor end of the turbine is mounted on a section of I beam, the web of which allows sufficient flexibility for the expansion of the turbine casing in the longitudinal direction.

THE FIRST of the Aldred Lectures at the Massachusetts Institute of Technology, established by J. E. Aldred, who carried to a successful conclusion the immense hydroelectric development at Shawinigan Falls on the St. Maurice River in Canada, is announced for the afternoon of Nov. 9. Gerard Swope, a Technology graduate of the class of 1895, president of the General Electric Company, will deliver the first of the lectures. Other eminent industrialists and engineers are to complete the program for the first year which consist of 12 lectures.

Do You Know This Man?

IN THE attempt to locate the family and friends of an amnesia patient, the Social Service Department of the Charity Hospital, New Orleans, La., is asking the help of engineers. The name of the patient is either Howard Grimes or G. L. Mahon. He cannot recall family or friends, but remembers having traveled extensively in the United States and Latin-America and believes that it was in connection with inventories of hydroelectric-plant equipment. In conversation with an engineer recently, he revealed a broad knowledge of power-house equipment.

"Mr. Grimes" is about 5 ft. 8 in. tall, weighs 140 lb., has a florid complexion, reddish brown hair, blue eyes, perfect teeth, and is freckled on face and arms. He is probably about 30 yr. old, is well educated and speaks Spanish. He is thoroughly familiar with New York and vicinity. He recalls having been in Vera Cruz, Tampico, Mexico City, Havana, Buffalo, Rochester, Chicago, Denver, Boston, Hartford, Bridgeport, Richmond, Newport News, Charlotte, Atlanta, Savannah, and Jacksonville.

On a card which he carried was inscribed Howard Grimes, Jacksonville, Fla., state distributor for the Allco Rim Tool Co. He was employed by this company before going to New Orleans, where he collapsed at the Planter's Hotel, but they were unable to furnish any further information concerning him.

Second Power Show Promises to Excel that of Last Year

IN NUMBER, diversity and interest, the exhibits of the Second Exposition of Power and Mechanical Engineering promise far to excel those of the first exposition held in December, 1922. The 1923 exposition is to be held in the Grand Central Palace, New York City, from Monday, Dec. 3, through Saturday, Dec. 8. The week of the exposition will be an active period for engineers for during that time meetings of the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers will be held. In addition, the National Association of Stationary Engineers, and its affiliated bodies, is organizing the interest of its membership, for last year these men found the exposition to be of great educational value.

The exhibits will be supplemented by an extensive program of moving picture films to be presented in co-operation with manufacturers. Last year the picture program was found to interest the layman who was not informed about technical processes and the engineer whose close application to one field of his work had not enabled him to keep up with progress in the rest of the profession.

About 200 exhibitors have signed contracts for space at the exposition.

Tool Facilitates Cleaning Undercut Commutators

FOR use in connection with cleaning undercut commutators the Martindale Electric Co., of Cleveland, Ohio, has recently imported from England and is marketing a cleaning tool such as is shown in the accompanying illustration.

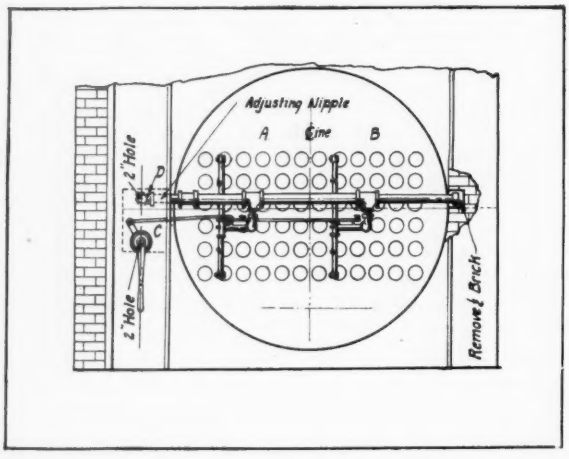
One edge of each blade has sharp teeth to remove obstructions, while the other edge is smooth and rides

GUIDE FITS INTO SLOT ADJACENT TO ONE BEING CLEANED

in the adjacent slot as a guide. The distance between the blades is adjustable to correspond to the width of the commutator bars. By raising or lowering the handle the depth of the cut can be regulated, and it is also possible to reverse the position of the tool since cutting edges are provided on each blade.

Gardner Soot Blower

THE GARDNER soot blower for fire-tube boilers, which has just come to our notice, embodies some rather novel features for this type of apparatus and is



GARDNER SOOT BLOWER INSTALLED ON HORIZONTAL RETURN TUBULAR BOILER

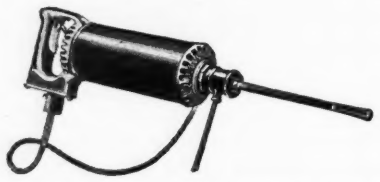
worthy of some note. Ordinarily it is made for installation on horizontal return tubular boilers. As shown in the accompanying sketch, it consists of a steam main extending across the uptake end of the boiler. This line is provided with two tees, opposite the center of each half of the tube sheet, which carry swivel joints and short radius leads which swing in a horizontal plane. At the end of each of these radius pieces is a vertical pipe carrying a number of venturi nozzles opposite each horizontal row of tubes. The radius pipes are connected by a distance piece which is operated through a bell-crank by a lever on the boiler front.

In operation, these nozzles are swung across the tube sheet, dwelling a few seconds—five is said to be enough—opposite each vertical row of tubes. The jets blow against the draft and the soot which is dislodged returns through the other tubes, with the draft, and is discharged up the stack. To increase the draft while the cleaning is being done, a number of stationary nozzles are provided which blow directly up the stack.

Solenoid Principle Used in Electric Hammer

REVERSAL of polarity, due to alternating current, furnishes the operating power for a recently developed electric hammer. A solenoid causes a tool steel piston to vibrate in synchronism with the frequency of the supply voltage which in the case of 60-cycle current means that 3600 blows per min. are struck.

Tests on this hammer have shown that when equipped with a star drill it will drill a 1-in. hole 3 in.



ON 60-CYCLE CURRENT, THE CORE STRIKES THE STAR DRILL 3600 TIMES PER MIN.

deep in dense concrete in one minute. Drills varying from ¼-in. to 1¼-in. diameter may be used or the hammer can be equipped with chisels.

Hammers of this type are being manufactured by the National Electric Manufacturing Co., of Pittsburgh, Pennsylvania.

Engineers to Push Government Reorganization Program

PLANS are under way for the launching of a nation wide movement under the leadership of the Federated American Engineering Societies to bring about the adoption by Congress of that portion of the government reorganization program which has to do with the Department of the Interior. As there seems to be a possibility that the plan as a whole will fail of adoption, engineers have decided to put forth all their effort in support of the consolidation of the functions of the Department of the Interior in a division of public works and a division of the public domain.

In general, the plan calls for the co-ordination of all engineering and construction activities of the government except military into the proposed division, and a general conference on this subject will be called in connection with the annual meeting of the societies in Washington in January, to which delegates from all engineering societies will be invited. It is planned to draft and have introduced into Congress a special bill which will provide for the adoption of the part of the Brown reorganization plan which has to do with the Department of the Interior, and to exert every effort to secure the passage of that bill.

News Notes

As a result of the recent American Society of Mechanical Engineers election, the following officers have been chosen: President, Fred R. Low, New York, N. Y.; vice-presidents, H. Birchard Taylor, Philadelphia, Pa.; George I. Rockwood, Worcester, Mass.; W. J. Sando, Milwaukee, Wis.; managers, E. O. Eastwood, Seattle, Wash.; E. R. Fish, St. Louis, Mo.; F. A. Scott, Cleveland, Ohio; treasurer, Wm. H. Wiley; delegates to American Engineering Council: F. K. Copeland, Chicago, Ill.; J. T. Faig, Cincinnati, Ohio; R. E. Flanders, Springfield, Vt.; Dexter S. Kimball, Ithaca, N. Y.; W. B. Powell, Buffalo, N. Y.; Wm. Schwanhausser, New York, N. Y.; S. W. Stratton, Cambridge, Mass.; C. C. Thomas, Los Angeles, Cal.; P. F. Walker, Lawrence, Kan.

Resignation of Mortimer E. Cooley, dean of the College of Engineering and Architecture of the University of Michigan, as president of the American Engineering Council of the Federated American Engineering Societies was announced at the opening session of a 2-day meeting of the executive board of the council held in Rochester, N. Y., Oct. 12. Dean Cooley, in presenting his resignation to the board, said that he retires on account of ill health. He also made it known that he has been granted leave of absence by the University of Michigan for the second half of the academic year of 1923-24.

Charles Piez, president of the Link-Belt Co., Chicago, announces the purchase of the Meese & Gottfried Co., of San Francisco, Los Angeles, Seattle and Portland. For the past 10 yr., Link-Belt Co. has been distributing its products on the West Coast through its subsidiaries, the Link-Belt Northwest Co., of Seattle, and the Link-Belt Pacific Co., of San Francisco. The new organization will be known as Link-Belt Meese & Gottfried Co., with headquarters at San Francisco.

Joel S. Coffin, chairman, and Samuel G. Allen, vice-chairman, Lima Locomotive Works; Joseph B. Terbell, president, American Brake Shoe & Foundry Co., and F. F. Fitzpatrick, president, Railway Steel Spring Co., have been elected to the board of directors of the International Combustion Engineering Corporation. Mr. Coffin will be chairman and Mr. Allen, vice-chairman, of the executive committee.

Manning, Maxwell & Moore announce that Walter V. Lawton has been appointed district manager of their Boston district with headquarters at the Textile Building, Boston, Mass. Joseph Wainwright has been appointed sales manager and W. C. Chapman, district manager, of the Philadelphia district with headquarters at the Pennsylvania Bldg., Philadelphia.

Detroit Stoker Co. announces the appointment of E. L. Beckwith as district manager in charge of the company's Chicago office, address Illinois Merchants Bank Building, Chicago.

McClave-Brooks Co., Scranton, Pa., has appointed S. Thomas as its western district manager, with headquarters at Chicago. Mr. Thomas was formerly connected, in the capacity of combustion engineer, with the Goodyear Tire & Rubber Co., the DuPont Powder Co., and more recently with Day & Zimmerman, Inc. A. J. Frett will continue as assistant manager of the Chicago office, and E. D. Bradley has joined the Chicago sales force.

Blake D. Hay, who has been with the Williams Tool Corporation at Erie, Pa., for some time, has been appointed Chicago district manager. He succeeds E. L. Mey, resigned.

Martin W Burke, for the past 20 yr. associated with the Bangor Water Works, has been appointed chief engineer for the company. He succeeds John W. Dougherty, deceased.

Fryeburg Electric Co., of Fryeburg, Me., has been purchased by the Western Maine branch, with headquarters at Limerick, Me., of the Cumberland Light & Power Co., of Portland, Me. The new owners will start at once on the preparation of plans for the erection of a new power house on the easterly side of Swan's Falls.

On Sept. 24 the Federal Power Commission gave to a committee of nine members from the state of Arizona, headed by Governor W. P. G. Hunt, an opportunity to present the so-called Arizona plan for the development of the Colorado River within the boundaries of that state. Concurrently the commission gave a hearing to James B. Girand upon his application for a license for a water-power project in the Colorado, to be located at Diamond Creek in Arizona, and to opponents to the granting of Mr. Girand's application. No action was taken by the commission at the conclusion of the hearing. The matters presented will be studied by the commission's staff, and will probably receive consideration at the next meeting of the commission.

Books and Catalogs

Kent's Mechanical Engineers' Handbook; tenth edition, rewritten by Robert Thurston Kent and a staff of specialists. XVI + 2247 pages, 4¼ by 7, illustrated; leather or atholeather binding; New York, 1923.

Like the return of an old friend, the new Kent is certain to receive a hearty welcome from all engineers who have found past editions of this work so useful. For years Kent's Handbook has been the standard of reference among mechanical engineers in this country and the excellent character of the new edition should make it more valuable than ever.

For three years Robert T. Kent, son of the original author, and new editor-in-chief, together with a staff of 35 of the most prominent engineers in the country, have been working on the new edition. Like its predecessors, the new Kent is essentially a handbook of engineering practice. Its function is to save time for the engineer.

The book has been completely revised from cover to cover, and contains many new subjects, such as Aeronautics, Automobiles, Heat Insulation, Reinforced Concrete, Safety Engineering and Machine Design. Other sections which have been rewritten so as to be practically new are Strength of Materials, Iron and Steel, Non-Ferrous Metals and Alloys, Steam Power, Gas and Oil Power, Hoisting and Conveying, Building Construction, and Heating and Ventilating.

Several features of the book are worthy of attention. Where new constants have been discovered, the tables depending on these constants have been recalculated.

This applies particularly to all the tables relating to the use of steam, which have been made to agree with the Goodenough steam tables used in the present edition. In the arrangement of the book, care has been taken to bring on the same page or facing page, the reference and the table, formula or illustration to which it refers. In presenting formulas, the notation of the formula is given immediately below the formula instead of at the head of a section.

In the new edition is contained over 50 per cent more material than in the previous edition. There are 14,565 titles included in the entire index and throughout the book are 605 cross references. No time is lost in finding the desired information.

Throughout the entire book, the usual high standards set by the previous editions have been strictly adhered to, and in spite of its modern and up-to-date character the fundamental ideas of the founder, William Kent, have not been violated in the slightest degree.

UNION DIESEL ENGINES are covered in bulletins Nos. 56 and 57 from the Union Gas Engine Co., of Oakland, Calif.

GETTING A COAL RATE of 2 lb. per kw.-hr. from a 28,000-kv.a. plant is the subject of a folder recently issued by the Heine Boiler Co., of St. Louis.

CIRCULAR B of Templeton Bros., Boston, Mass., illustrates and describes its line of return traps for boiler feeding and pumping, draining vacuum line and creating vacuum on low pressure return lines.

MANUALLY OPERATED mechanical stokers are described in a bulletin recently issued by the CoKal Stoker Corp., of Chicago, Ill. The CoKal stoker, which is of the hopper-feed chainless type, is described and its application to various types of boiler settings illustrated.

MCCLAVE-BROOKS CO., of Scranton, Pa., is distributing the first of a new series of catalogs which will describe the products manufactured by this organization. These bulletins are to be enclosed in a loose-leaf folder and the first one issued covers the McClave mechanical stoker for all grades of bituminous and lignite fuels.

PNEUMATIC SEWAGE EJECTORS operated on the Shone System are described in bulletin No. P-4200, now being distributed by the Yeomans Bros. Co., of Chicago. This bulletin contains information on the new type of Shone ejector in which the piston valves are detached from the ejector and located outside of the ejector pit.

RILEY UNDERFEED STOKERS are covered in a new 64-page catalog recently issued by the Sanford Riley Stoker Co., of Worcester, Mass. Besides illustrating and describing the construction of the underfeed stokers, a considerable amount of general information on combustion is also given in the bulletin. Some of this engineering data includes installation information, sizes of chimneys, evaporation curves and photographs of typical Riley installations.

STRAINERS of the twin, single and intake types are discussed in catalog A-2 now being distributed by the Elliott Co., of Jeannette, Pa. Strainers of these types are used in removing solid foreign matter from water used for power and industrial plants which obtain their water supply from natural sources. The twin strainer consists of two straining chambers in one body, arranged in such a way that the straining chambers are alternately thrown in and out of service by operating the two valves. Tables of dimensions are given and construction details are shown.

FLEXIBLE INSULATED COUPLINGS are covered in booklet "F" of the Chas. Bond Co., Philadelphia, Pa. Couplings of this type are adapted for motor generator sets or for connecting motors to pumps and other such uses.

RECORDING AND INDICATING TACHOMETERS are described in bulletin No. 317 now being distributed by the Bristol Co., of Waterbury, Conn. Both the pneumatic and the electric types are discussed in this bulletin.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.,

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly, at Chicago, Ill., for October 1, 1923.

State of Illinois
County of Cook
ss.

Before me, a Notary in and for the state and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, none.
Business Manager, E. R. Shaw, Chicago, Ill. .

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of the stockholders owning or holding 1 per cent or more of the total amount of stock.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
A. L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has an interest, direct or indirect, in the said stocks, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is..... (This information is required from daily publications only.)

Chas. Sanford Clarke, Secretary.

Sworn to and subscribed before me this 28th day of September, 1923. Robt. R. Greig.

(My commission expires October 27, 1923.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher, to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the postoffice. The publisher must publish a copy of this statement in the second issue printed next after its filing.